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GROUND-WATER RESOURCES

of the

MORA RIVER DRAINAGE BASIN,

western Mora County, New Mexico

by J. W. MERCER
E. G. LAPPALA

COLFAX COUNTY
MORA COUNTY

Mora

Chacon

Coyote

Guadalupita

Creek

105°30'

Lucero

River

COUNTY
MORA COUNTY

TAOS
MORA

105°00'

38°
00'

MORA

FORT
UNION

Optimo

105°30'

104°30'

River

Mora

Watrous

MORA COUNTY
SAN MIGUEL COUNTY

105°00'

104°30'

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J. W. MERCER
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United States Geological Survey

1972

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GROUND-WATER RESOURCES OF THE MORA RIVER DRAINAGE BASIN,

WESTERN MORA COUNTY, NEW MEXICO

By

J. W. Mercer and E. G. Lappala

ABSTRACT

Shortages of surface water for irrigation during the latter part of the growing season have limited agricultural development in western Mora County in northwestern New Mexico. This report describes the possibilities for developing ground water for supplementary use.

The rocks that underlie western Mora County range in age from Precambrian to Holocene. Rocks of Precambrian age, mostly middle-grade metamorphics and granite intrusives, crop out in the western part of the area. Shales, sandstones, and interbedded limestones of Paleozoic and Mesozoic age crop out over large parts of the remainder of the area. These rocks contain only small localized supplies of ground water. In the north-central and eastern sections of the project area the sedimentary rocks are overlain locally by basalts of Tertiary to Quaternary age.

In nearly all of the Mora River drainage, unconsolidated Quaternary deposits of alluvial, colluvial, lacustrine, and glacial(?) origin fill the stream valleys and contain ground water. Thicknesses of these deposits range from a few feet in tributary valleys to more than 300 feet in the Mora Valley in western Mora County. This thickness in Mora Valley seems to be the result of late Cenozoic downwarping and/or faulting with concurrent river deposition by a south-flowing river during Pleistocene time.

Test drilling, driller's logs, and aquifer tests

indicate that unconsolidated materials filling the valleys above Watrous are heterogeneous and anisotropic. Maximum transmissivity and storage coefficient values for these areas are 40 ft^2/day (square feet per day) and 0.05, respectively. Although the total storage of ground water in the upper valleys (exclusive of Mora Valley) is about 12,700 acre-feet, it is doubtful if adequate irrigation supplies could be maintained because the saturated thickness of the aquifers is generally not sufficient to permit wells to be pumped at rates practical for irrigation. A limited potential for irrigation exists in Mora Valley because of local saturated thicknesses of as much as 200 feet; however, verification of potential awaits drilling of test holes and substantial testing of the aquifer by pumping.

Ground-water development appears to be feasible in the alluvial valley near Watrous. Unconsolidated deposits in this area are relatively homogeneous and isotropic. Transmissivity values range from 3,400 to 20,000 ft^2/day, and the assumed maximum storage coefficient value is 0.2. The amount of ground water in storage is about 4,000 acre-feet. Annual withdrawals taken from aquifer storage by pumpage would be substantially replaced by recharge from the river and by return flow from irrigation water. However, should more development of ground water occur, it would eventually deplete streamflow by an amount equal to the increased consumptive use less the amount of water which might be salvaged.

The movement of ground water in the alluvial deposits is generally towards the surface-drainage system. In the upper alluvial valleys rates of movement range from 0.03 to 0.1 foot per day. In the Watrous area rates of movement range from 1 to 10 feet per day.

The chemical quality of both surface and ground water throughout the alluvial valleys of western Mora County meets the established criteria for irrigation use.

INTRODUCTION

This report presents the results of an investigation of the ground-water resources of the Mora River drainage in western Mora County, New Mexico. The investigation was endorsed by the Steering Committee of the Adelante Resource Conservation and Development Project, an organization

formed by the people in the area to encourage development
of the resources of Mora County. The investigation is a co-
operative effort of the U.S. Geological Survey, the U.S.
Soil Conservation Service, the New Mexico State Engineer
Office, and the Four Corners Regional Commission.

Purpose and Scope of the Investigation

The upper part of the Mora River drainage basin has a
history of shortages of surface water for irrigation during
the latter part of the growing season. This shortage is
one of several factors which tends to limit agricultural
products to marginal cash crops such as alfalfa, small
grains, and corn. If additional irrigation water was
available during critical periods the crop pattern could be
shifted to the growing of higher value crops such as fruits
and vegetables. Such crops would yield greater returns per
acre, thus permitting achievement of increased economic
stability. One possibility of alleviating irrigation-water
shortages would be the use of wells to supplement surface-
water supplies during periods of low streamflow.

Preliminary investigation determined that alluvial de-
posits in the stream valleys were the most likely source of
additional water for irrigation needs. It is the primary
purpose of this study to determine if and where ground water
is present in alluvial deposits in sufficient quantity and
of suitable quality to enable the development of supple-
mental irrigation wells.

The study has, as a secondary objective, the deter-
mination of principal factors affecting ground-water irrig-
ation and development, surface water availability, consump-
tive-use requirements of different crop types, and present
and potential drainage problems in irrigated areas.

Field investigations were begun by Geological Survey
personnel in November 1968 and completed in October 1969.
Records of wells and springs were collected, water levels
in wells were measured, water samples were collected for
chemical analysis, aquifer tests were made, surface-water
records were obtained, alluvial deposits were mapped, and
seismic-refraction studies were made to obtain the thick-
ness of the alluvial deposits. Surface geology was com-
piled from existing maps and photogeologic mapping was done
where needed. A network of 44 observation wells was estab-

lished in the area of study. These wells were measured monthly to determine changes in water levels between the irrigation and nonirrigation seasons.

Basic data for wells and springs in the study area were collected by E. F. Rush and J. L. Hughes, U.S. Geological Survey, Carson City, Nevada, and W. D. Purtymun. The remainder of the field work (including the seismic refraction study), interpretation of data, and compiling of the report was done by J. W. Mercer and E. G. Lappala.

The results of the seismic refraction studies, contained in a separate report by Mercer and Lappala (1970), are used freely in this report.

Location and Extent of the Area

Mora County is in the northeast quarter of New Mexico. The alluvial valleys described in this report are the valleys occupied by the Mora River and its tributaries in the western part of the county upstream from the U. S. Geological Survey gaging station on the Mora River which is 4.5 miles east of the community of Shoemaker (fig. 1).

The Mora River and its tributaries head in the Sangre de Cristo Mountains, which form the western boundary of the basin, and drain approximately 900 square miles in the project area. The Mora River joins the Canadian River 23 miles downstream from the gaging station east of Shoemaker. Altitudes range from more than 12,000 feet at the headwaters to 6,170 feet at the gaging station.

The principal communities in western Mora County are along the main stem of the Mora River and include Chacon, Cleveland, Holman, Mora (the county seat), and Watrous.

Acknowledgments

The authors express their appreciation to W. L. Shaffer of the Geological Survey for his assistance in data reduction and analysis of seismic data, and to R. T. Zbur of the U.S. Air Force Weapons Laboratory, Kirtland Air Force Base, for the use of equipment and for technical assistance. J. C. Yates, P. D. Akin, Zane Spiegel, and R. L. Borton of the New Mexico State Engineer Office are thanked for tech-

EXPLANATION

Alluvial deposits in upper valleys, exclusive of Mora Valley.

Alluvial deposits in the Mora Valley.

Alluvial deposits from Valmora to gaging station.
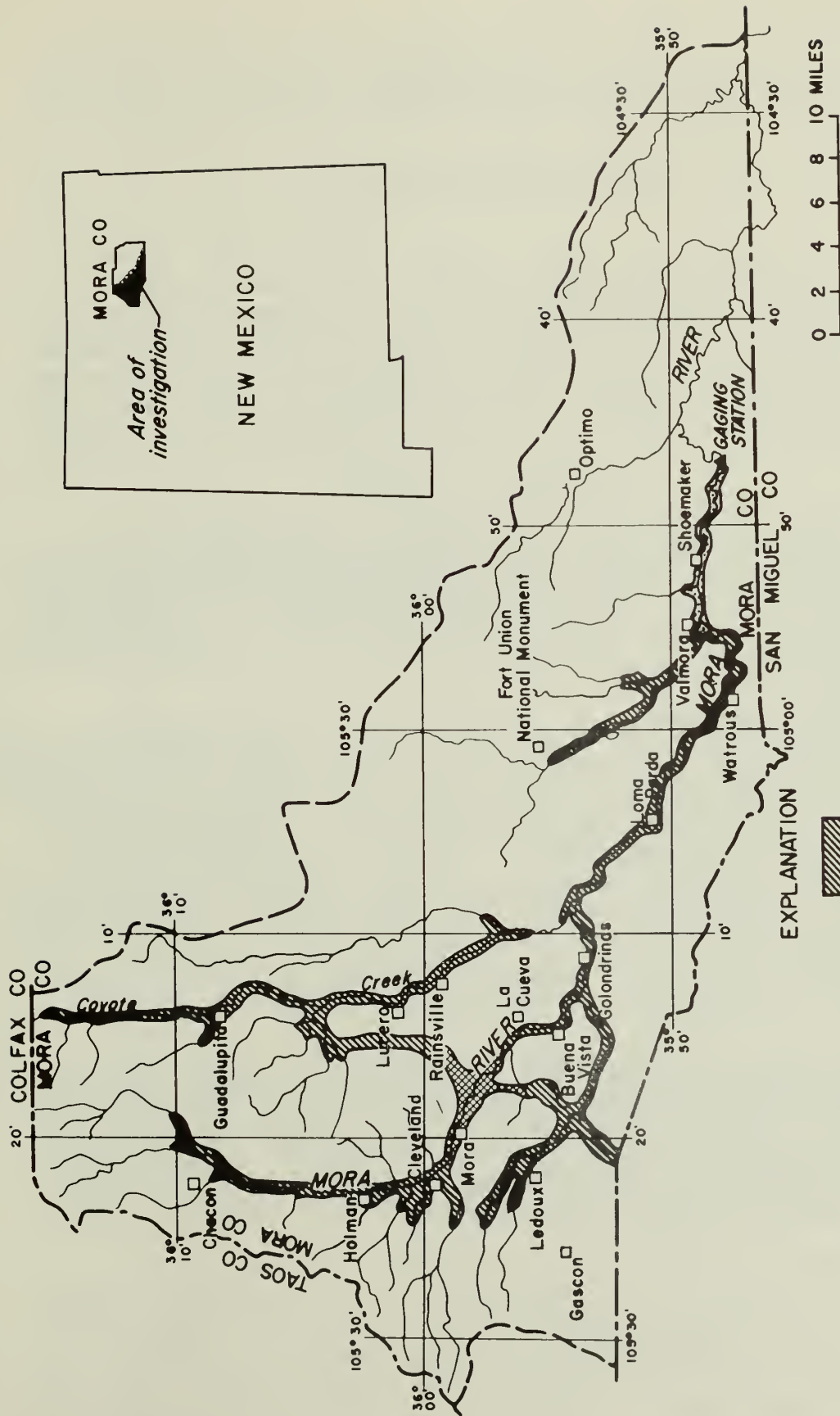
FIGURE 1.--Index map.

nical review of this report.

We also thank the people of Mora County for granting access to their property during the field investigation.

Previous Investigations

The earliest geologic reports of the area, Stevenson (1881), Lindgren and others (1910), and Darton (1928), were of a general nature and discussed the southern Sangre de Cristo Mountains. Northrop and others (1946) and Bachman (1953) included parts of the area in large scale geologic mapping for oil and gas. Zeller and Baltz (1954) described the sedimentary copper and uranium deposits in the Coyote district along Coyote Creek, a tributary of the Mora River.

Baltz and Bachman (1956) mention the geology in the Mora River drainage in a discussion of the Sangre de Cristo Mountains for the seventh field conference of the New Mexico Geological Society. Baltz (1965) discussed in detail the stratigraphy of the upper Mora drainage in a summary article on the geology of the Raton Basin.

The first report concerned with the water resources was a reconnaissance study made by the U.S. Bureau of Agricultural Economy in 1941. Their concern was with rehabilitation of the water-conveyance system and with the possibilities of building dams for supplemental storage. The U.S. Bureau of Reclamation (1955) compiled a summary of the work previously done and included the feasibility and economic justification for rehabilitating the existing irrigation facilities. A hydrology supplement to previous reports on the Mora drainage basin was compiled in 1966 by the Bureau of Reclamation.

The first investigation concerned with ground-water resources was by Spiegel (1955), New Mexico State Engineer Office, who made a study concerned with water supplies for the communities of Holman and South Holman. A study was made by Winograd (1956) to locate a water supply for Fort Union National Monument near Watrous.

GEOGRAPHY

Physiography and Drainage

The study area is characterized by broad, elevated,

north-trending belts of Precambrian crystalline rocks
generally flanked by steeply dipping sedimentary rocks.
The Sangre de Cristo Mountains are the predominat feature
of this part of New Mexico. The topography of the eastern
part of the study area is characterized by high mesas,
extensive dissected plateaus, and volcanic mountains and
flows of various ages.

The area of study lies entirely within the watershed
of the Mora River. The Mora and its major tributaries,
Coyote Creek, Rito Cebolla, and Rio la Casa are normally
perennial streams. The Mora River drains eastward to the
Canadian River, a tributary of the Arkansas River.

Economic Development

The following statistics (written commun., Four
Corners Regional Commission, 1968) for Mora County are
representative of the economy of the western part of the
county.

Category	Period	Trend in percent
Population change	1960-64	+ 3.3
Total employed	1960-64	-17.1
Agriculture	1960-64	-24.2
Non-agriculture	1960-64	- 6.7
Farm income	1960-64	-17.3
Acreage devoted to farming	1940-64	No significant change
Acreage devoted to cash crops	1960-64	-35.0

The economy is primarily one of subsistence-level
farming based on surface-water irrigation which has been
practices for many years. Crops raised are mostly alfalfa,
corn, and hay with large areas devoted to vega or natural
pasture on which livestock are grazed. Some small scale
logging operations provide sawlogs for local mills.

Studies in the southwest (U.S. Bureau of Reclamation,
1966, and Houk, 1951) have shown the consumptive-use
requirements (amount of water consumed by crops) (table 1)
are generally less for truck crops in the irrigated areas
than for forage crops, small grains, and corn.

TABLE 1.--Ranges in consumptive-use requirements
for truck, forage, and small grain crops
in the Mora River drainage, western Mora
County, N. Mex.

Crop	Range in consumptive-use requirements1/ (acre-feet per acre)	Crop	Range in consumptive-use requirements 2/ (acre-feet per acre)
Beans, snap	0.83-1.44	Alfalfa	1.74-2.22
Beets, table	0.87-1.37	Small grains	1.15-1.18
Cabbage	0.94-1.49	Corn	1.36-1.80
Carrots	1.27-1.60	Grass, hay, pasture	1.56-1.98
Cauliflower	1.43-1.77	Vega	1.56-1.98
Lettuce	0.72-1.35	---	---
Onions	0.73-1.52	---	---
Peas	1.21-1.56	---	---
Spinach	0.80-1.07	---	---
Tomatoes	0.95-1.42	---	---

1/ Houk (1951, p. 357)

2/ U. S. Dept. of the Interior (1966)

Climate

The following climatological data are taken from
"Climatological Summary of New Mexico" published annually
by the U.S. Weather Bureau. Records of six weather stations
in western Mora County and one at Black Lake, Colfax County,
have been included (fig. 2).

The climate of western Mora County is semi-arid,
typical of high mountain valleys within northern New Mexico.

FIGURE 2.--Location of meteorological and stream-gaging stations.

EXPLANATION

ϕ^2

Precipitation station,
storage gage

1 - Black Lake
2 - Chacon

$-O^5$

Precipitation and temperature
station, nonrecording

3 - Gascon
5 - Ft. Union
6 - Valmora

O^7

Precipitation station,
nonrecording

4 - La Cueva
7 - Optimo

$\blacktriangle^8$

Existing gaging station

1 - Mora River near Holman
4 - Rio la Casa near Cleveland
5 - Mora River at La Cueva
7 - Mora River near Golondrinas
8 - Coyote Creek above Guadalupita
10 - Coyote Creek near Golondrinas
12 - Mora River near Shoemaker

$\triangle^6$

Discontinued gaging stations

2 - Vigil Canyon near Holman
3 - Agua Fria Creek near Holman
6 - Cebolla River (Rito Cebolla) near Golondrinas
9 - Coyote Creek at Guadalupita
11 - Mora River near Watrous
13 - Mora River near Cleveland

Note: D beside precipitation symbol
indicates discontinued station

Average annual precipitation varies from 15.5 inches at Optimo to greater than 22 inches in the mountains along the western boundary of the county. Commonly 30 to 40 percent of the average annual precipitation occurs in July and August from convectional summer storms (fig. 3). The occurrence of these storms varies greatly, resulting in a large variation in areal distribution of late-summer precipitation.

Summers are cool and winters mild. The warmest months are July and August; December and January are the coldest (fig. 4).

GEOLOGY

Stratigraphy

The rocks that underlie western Mora County range in age from Precambrian to Holocene. Basement rocks of Precambrian age crop out in the western part of the area where they consist of middle-grade metamorphics and granite intrusives. Rocks of Paleozoic and Mesozoic age, Devonian through Cretaceous, crop out over large parts of the remaining area and consist of shales, sandstones, and some interbedded limestones. These deposits generally constitute the bedrock of the area. The sedimentary rocks in the north-central and eastern sections of the Mora River drainage are locally overlain by basalt flows of probable late Tertiary to Quaternary age. Unconsolidated sedimentary deposits of Cenozoic age, mostly Holocene, fill the stream valleys and locally form veneers on low terraces. A thicker deposit of Pleistocene age occurs in the valley trending northeastward from Mora.

The thickness, lithologic character, and water-bearing properties of the rocks that crop out in the Mora River drainage are given in the generalized geologic section (table 2). Three bedrock formations--sandstones in the Sandia Formation of Pennsylvanian age, the Santa Rosa Sandstone of Triassic age, and the Dakota Sandstone of Cretaceous age--furnish small amounts of water to wells. Most of the unconsolidated deposits of Quaternary age are water bearing; the areal extent of the unconsolidated deposits and bedrock formations adjacent to them are shown in plate 1.

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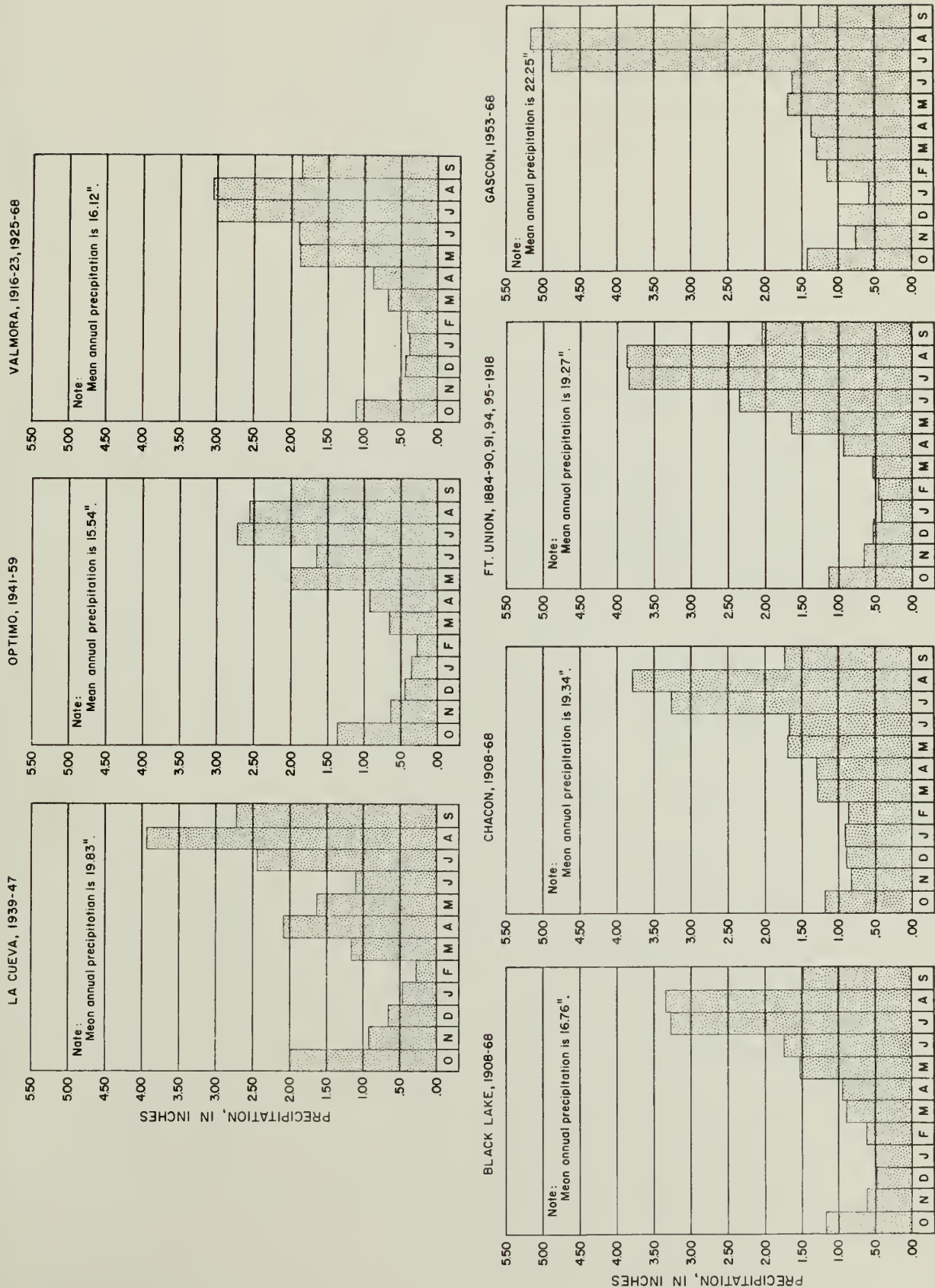
FIGURE 3.--Mean monthly precipitation for stations in the Mora River drainage.

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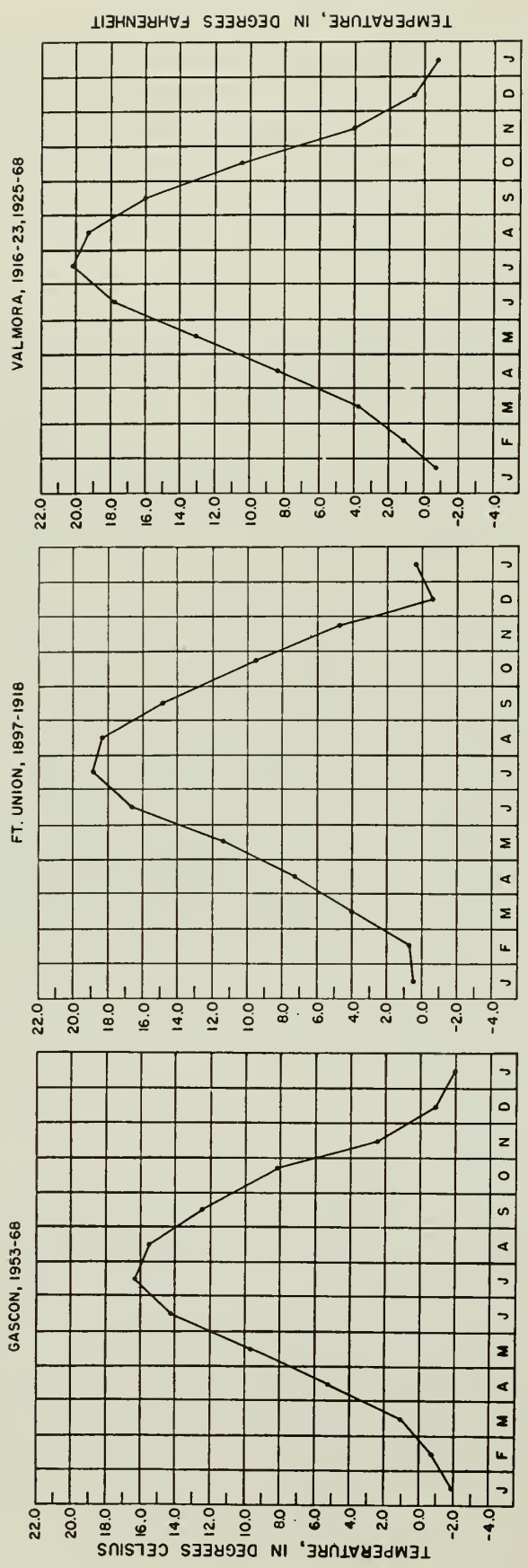
FIGURE 4.--Mean monthly temperature for periods of
record shown at Gascon, Ft. Union, and Valmora.

TABLE 2.--Summary of stratigraphic units and their water-bearing
properties in the Mora River drainage, western Mora County, N. Mex.

SYSTEM	SERIES	GROUP	STRATIGRAPHIC UNIT	THICKNESS (in feet)	LITHOLOGY	WATER-BEARING CHARACTER
Quaternary	Holocene		Alluvium	0-50	Unconsolidated deposits of valley fill. Chiefly gravel, sand, silt, and clay.	Generally yields small amounts of water for stock and domestic use. Near Watrous yields water sufficient for irrigation purposes.
	Pleistocene		Boulder deposits	--	Deposits of quartzite boulders. Fan built at mouth of Río la Casa is comprised of these boulders. Boulders are, in part, of glacial origin.	Unknown
			Pediment gravels	--	Veneer of unconsolidated gravel and sand deposited on stream-cut terrace surfaces.	Not known to yield water.
			Valley fill	0-32+	Sand, gravel, and silt.	Generally yields small amounts of water for stock and domestic use. Irrigation potential questionable.
Tertiary			Basalt	--	Gray, vesicular, olivine basalt.	Unknown
Cretaceous	Upper		Greenhorn Limestone	0-50	Dark-gray, finely crystalline limestone and interbedded dark-gray shale.	A few wells outside the project area produce water from the limestone.
	Lower		Graneros Shale	250±	Consists of dark- to medium-gray shale. Thin beds of argillaceous limestone are common.	Generally not water bearing.
			Dakota Sandstone	100-200	Consists of two sandstone beds separated by a shale unit. The sandstone beds are gray to tan and composed chiefly of quartz. Shale is dark-gray to black and carbonaceous.	Sandstone yields moderate supplies of water to domestic and stock wells.
Jurassic	Upper		Morrison Formation	150-400	Consists of varied proportions of red, gray, and brown sandstone and conglomerate; interbedded red, gray, and green shale; and thin local limestone beds.	Generally not water bearing.
			Entrada Sandstone	20-120	White to pink and red, fine- to coarse-grained, moderately well-sorted sandstone.	Yields water to a few stock wells.
Triassic	Upper	Dockum	Chinle Formation	600-900	Predominately red, purple, and greenish shale and siltstone with interbedded red, brown, and gray sandstone.	Sandstone yields small amounts of water. Generally highly mineralized.
			Santa Rosa Sandstone	250-450	Consists of thin to thick layers of brown, gray, and red sandstone and interbedded thin to thick red shale. Sandstone is very lenticular.	Yields moderate amounts of water. Generally under artesian pressure.

TABLE 2.--Summary of stratigraphic units and their water-bearing properties in the Mora River drainage, western Mora County, N. Mex. Concluded

SYSTEM	SERIES	GROUP	STRATIGRAPHIC UNIT	THICKNESS (in feet)	LITHOLOGY	WATER-BEARING CHARACTER
Permian	Upper and Lower		Bernal Formation	50-100	Pink, orange, and red siltstone; shale; fine- to coarse-grained sandstone, and some thin beds of limestone and gypsum.	Generally not water bearing.
	Lower		Glorieta Sandstone	275±	Gray, fine- to medium-grained, well-sorted, well-cemented, marine sandstone.	A few wells to the south of the study area yield small amounts of water to wells in the Mora drainage.
			Yeso Formation	0-400	Orange to brick-red siltstone and shale with interbedded fine-grained sandstone. Locally contains dolomite and gypsum.	Generally not water bearing.
Pennsylvanian	Upper		Sangre de Cristo Formation	700-4,000+	Red and green shale with interbedded arkose and conglomerate and a few thin beds of limestone.	Data on water-bearing characteristics are sparse.
	Upper and Middle	Magdalena	Madera Limestone	300-3,000(?)	Consists of two units: a lower gray limestone member composed of interbedded crystalline fossiliferous limestone, dark-gray shale and sandstone; an upper arkosic limestone member comprised of clastic limestone, red, green, and gray shale and conglomerate arkosic sandstone.	Generally not water bearing.
	Lower		Sandia Formation	300-4,000	Composed of cyclic variations of gray to black, thin- to thick-bedded limestone; gray to black calcareous and bituminous shales; impure coal; gray, red, and green siltstone; white to gray, brown sandstone, and gray conglomerate.	Sandstone beds contain small amounts of water. Water is generally mineralized and has an unpleasant odor.
Mississippian			Tererro Formation	0-130	Limestone breccia, marine conglomerate, clastic and crystalline limestone, and siltstone.	Generally not water bearing.
Devonian(?)			Espiritu Santo Formation	0-80	Thin dark-gray limestone, dolomitic limestone, sandy limestone, and a thin basal sandstone.	Generally not water bearing.
Precambrian					Metamorphic rocks intruded by pegmatites and granitic intrusions.	Generally not water bearing.

Structure

Structural features were developed by folding and thrusting in Late Cretaceous-Early Eocene time during the main Laramide disturbance, which was followed by Miocene and Pliocene high-angle faulting and later epeirongenic uplift (Gabelman, 1956). Structural activity during Miocene and Pliocene time resulted in the present form of the Sangre de Cristo Mountains.

Structural features have greatly controlled development of the present drainage. The river valleys, where Holocene alluvial deposits are concentrated, have formed in the less resistant rocks such as shales; bordering ridges have developed on the more resistant rocks such as sandstones and limestones.

The prominent valley trending northeastward from Mora was formed by block-faulting or by downwarping, which has preserved the present thick section (at least 322 feet) of alluvial deposits.

HYDROLOGY

The earth's water moves in a continuous system commonly
called the hydrologic cycle--from the atmosphere to the earth's
surface and back to the atmosphere (fig. 5). There are many
short cuts and detours in the hydrologic cycle. Some pre-
cipitation evaporates before it reaches the earth, thus by-
passing the surface and returning directly to the atmosphere.
Some precipitation soaks into the soil zone and is utilized by
by plants. Some becomes runoff in streams and rivers, flow-
ing to the oceans or to lakes and reservoirs. Some precipi-
tation moves down into the earth, below the soil and root
zone, to become ground water--a detour that may delay it for
long periods of time before it returns again to the earth's
surface. This report is concerned primarily with water in
the ground-water phase of the hydrologic cycle, and second-
arily with water in the runoff and plant-utilization phases.

Surface Water

The Mora River and its tributaries (Rio la Casa, Rito
Cebolla and Coyote Creek) drain approximately 900 square
miles within the project area. Thirteen U.S. Geological Sur-
vey gaging stations have been in operation intermittently in
western Mora County since 1905 (figs. 2 and 6). Figure 7
shows the streamflow in the Mora River to be typical of
streams in high mountain valleys of northern New Mexico,
having a runoff peak in late May due to snowmelt and another
peak in August due to summer convectional storms.

Base flow of the streams is sustained primarily by
natural ground-water inflow and by return seepage and over-
land flow from surface irrigation.

The natural flow regimen in the basin has been altered
considerably by numerous small diversions to the present
surface-water irrigation system. Natural streamflow is
augmented by two transmountain diversions for irrigation:
Rito de la Presa to Agua Fria Creek and Alamitos Creek to
Vigil Canyon, which together add about 5,000 acre-feet per
year to the flow in the Mora River. Water-use malpractices
such as failure to close headgates during the nonirrigation
season and water loss through delivery systems result in
reducing the flow of the streams.

With the exception of La Cueva and Red Lakes on the
Salman Ranch, surface storage within the basin is limited to
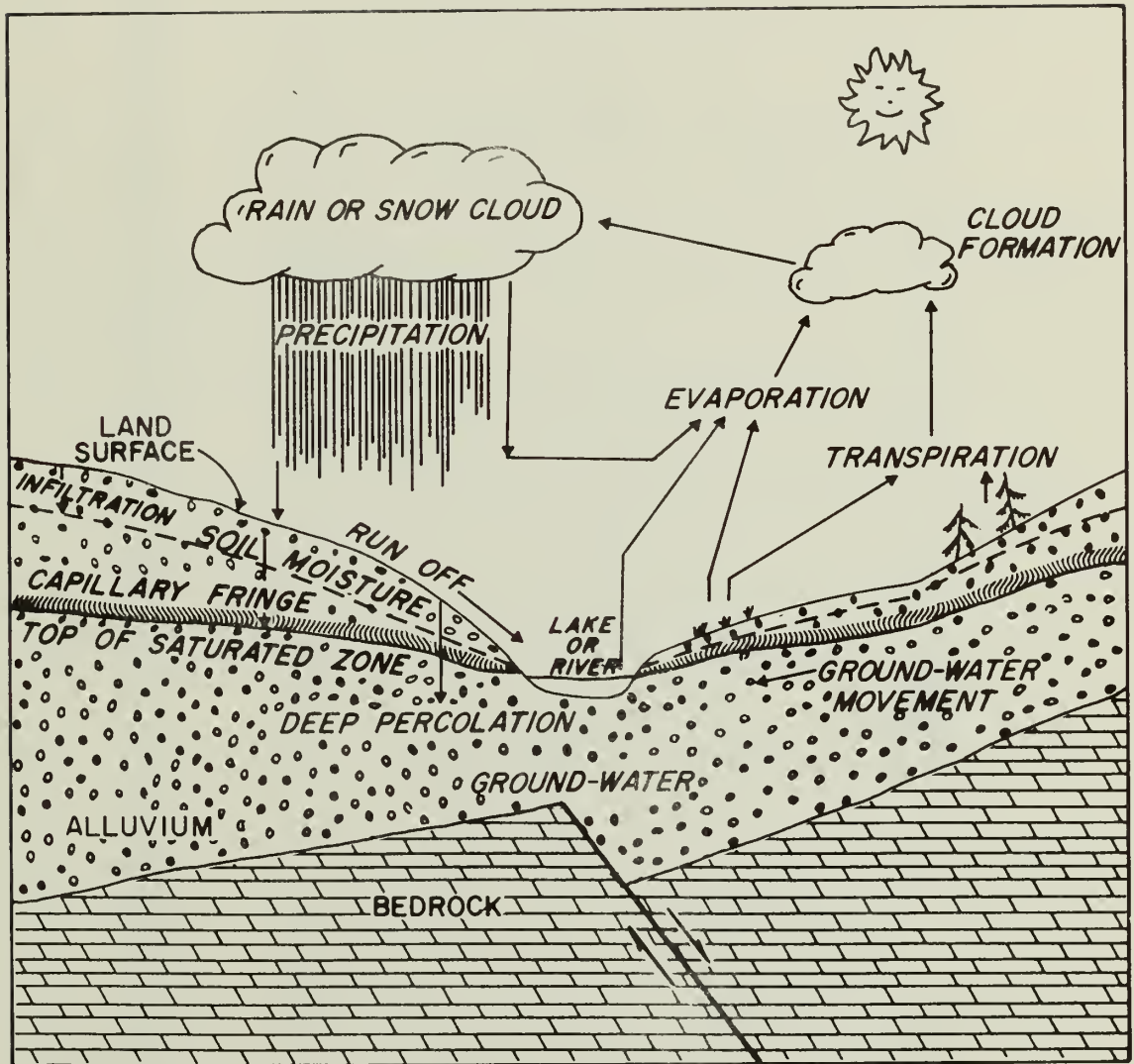
FIGURE 5.--Schematic representation of the hydrologic cycle.

STATION	DRAINAGE AREA (sq. mi.)	1900	1910	1920	1930	1940	1950	1960	1970	MEAN ANNUAL DISCHARGE (acre-feet)
Mora River near Holman	57									9,773
Vigil Canyon near Holman	2.8									1,262
Agua Fria Creek near Holman	9.2									3,930
Rio la Casa near Cleveland	23									10,068
Mora River near Cleveland	165									23,092
Mora River at La Cueva	173									21,313
Mora River near Golondrinas	267									25,231
Cebolla River near Golondrinas	64									4,053
Mora River near Watrous	521									38,943
Coyote Creek above Guadalupita	71									7,525
Coyote Creek at Guadalupita	89									8,644
Coyote Creek near Golondrinas	215									9,790
Mora River near Shoemaker	1104									45,626

FIGURE 6.--Periods of record and mean annual discharge for U.S. Geological Survey gaging stations in the Mora River drainage, western Mora County.
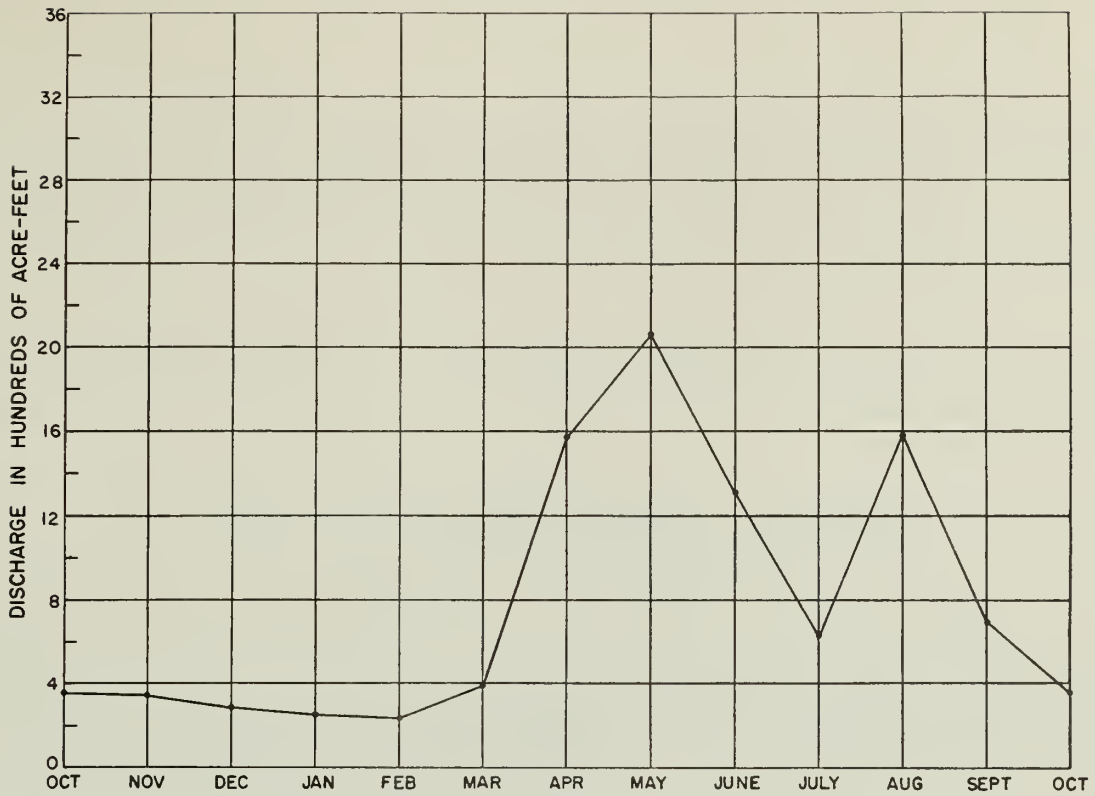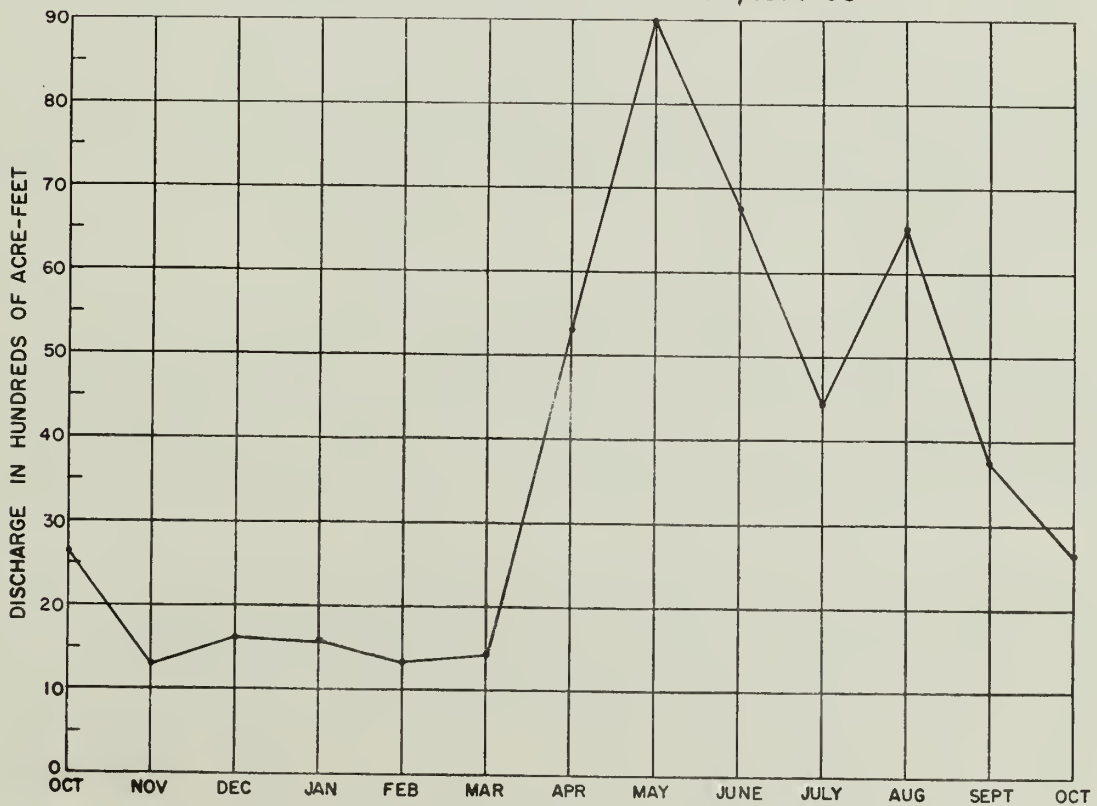
FIGURE 7.--Mean monthly discharge for periods of record,
Mora River near Holman and Mora River near Shoemaker.

small earthen irrigation tanks, stock ponds, and sumps. The present maximum volume in surface storage is approximately 57,000 acre-feet. This estimate was made using the total area covered by surface storage and assuming an average depth of 5 feet.

An extensive study of the surface-water regimen in the study area was conducted by the U.S. Bureau of Reclamation (1955 and 1966).

Ground Water

Principles of Occurrence

The principles of occurrence of ground water are discussed in detail by Meinzer (1923a, 1923b). Only a few general statements are made here for the purpose of the discussion that follows.

The source of all ground water in the project area is precipitation. Water that reaches the land surface as precipitation either evaporates, runs off as streamflow, or infiltrates downward into the earth where some of it may reach the saturated zone and becomes ground water (fig. 8). Rocks or unconsolidated materials that yield water to wells are called aquifers, and may consist of one or more geologic formations.

Water in an aquifer may be under confined or semiconfined (artesian) or unconfined (water-table) conditions. Confined or semiconfined conditions can occur when water in a permeable bed, such as sand, is overlain and underlain by less permeable confining beds such as silt, clay, or shale. Confined or semiconfined water is under hydrostatic pressure. If a well penetrates a confined or semiconfined bed the water will rise in the borehole; if it flows at the surface it is called a flowing artesian well; if the water rises in the borehole but does not flow it is called a nonflowing artesian well. The imaginary surface to which water rises in an artesian well is called the potentiometric surface. A good example of a nonflowing artesian well is the New Mexico State Highway Department well (well 73) near La Cueva. The well encountered water-yielding sandstones below 300 feet. In 1969 the water level in the well was 88 feet below the land surface.
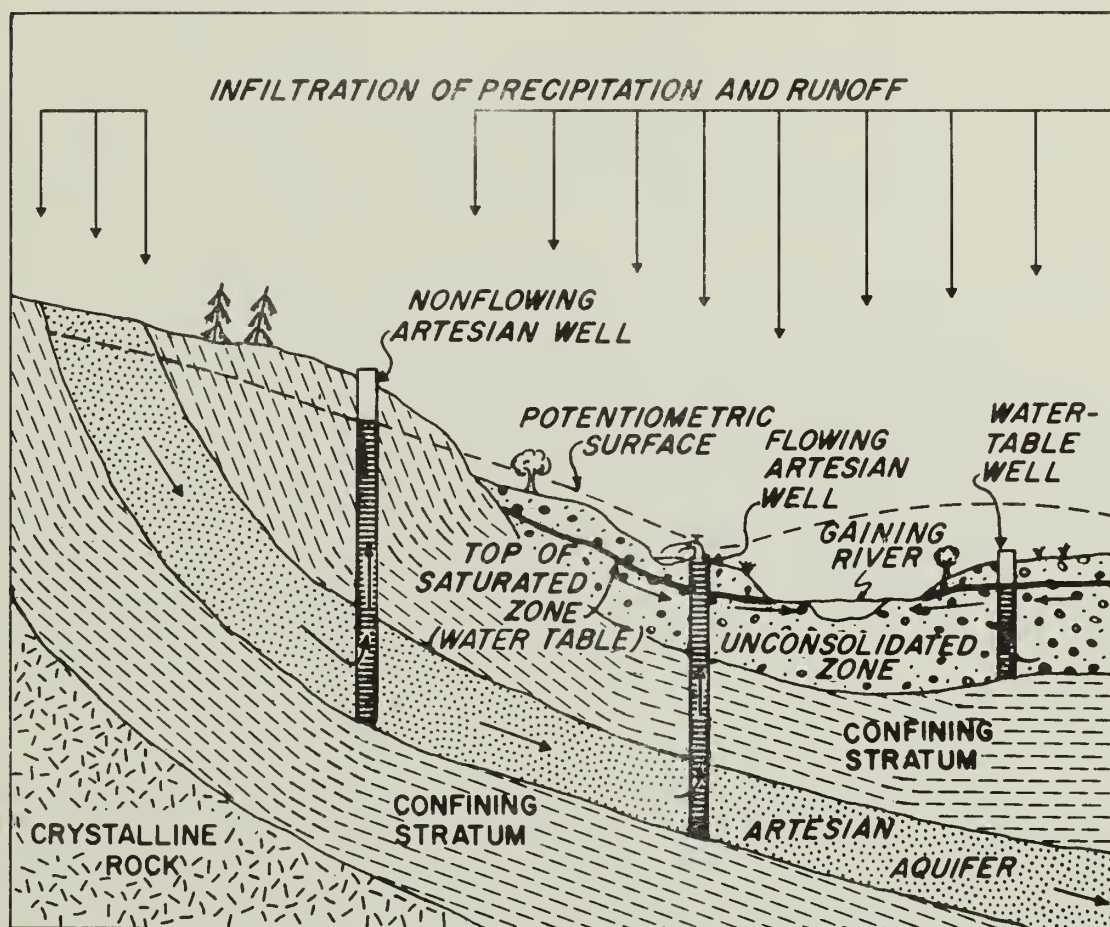
FIGURE 8.--Schematic diagram of the ground-water
phase of the hydrologic cycle showing the occur-
rence of semiconfined and unconfined water.

If water is unconfined, the upper boundary separating
the unsaturated zone from the saturated zone is called the
water table. At this "surface" (water table) the hydro-
static pressure in the ground water is atmospheric. Most
of the domestic and stock wells in western Mora County are
completed in unconfined aquifers.

Both confined and unconfined ground water generally
moves slowly toward points of discharge, either rivers,
springs, or an overlying formation by way of fractures in
confining beds. The infiltration, movement and discharge
is characteristic of the ground-water phase of the hydrologic
cycle (fig. 8). The natural discharge of aquifers provides
nearly all of the base flow of the perennial streams of the
western Mora County area.

Bedrock Aquifers

The ability of the bedrock aquifers in western Mora
County to yield water to irrigation wells is limited. Bed-
rock formations (table 2) that are saturated are either too
deep to be economically developed, have low yields, or com-
monly contain water of a quality undesirable for irrigation
use. For example, the Sandia Formation of Pennsylvanian
age which crops out in extreme western Mora County yields
4 gpm (gallons per minute) to well 11, south of Chacon. The
water has a conductance of 1,500 micromhos per centimeter.
East of La Cueva the Sandia Formation lies at depths in
excess of 3,300 feet.

The Santa Rosa Sandstone of Triassic age and the Dakota
Sandstone of Cretaceous age are shallower in depth, but
generally are tightly cemented and yields are not commensurate
with irrigation requirements. Well 142 north of Loma Parda
taps the Dakota Sandstone and yields 16 gpm.

The bedrock aquifers are recharged by precipitation
in outcrop areas and by infiltration from ephemeral and
intermittent streams where the aquifers immediately underlie
the stream channel. The ground water is discharged through
wells, springs, and to the perennial reaches of streams
(Appendixes A and B). Ground water in bedrock aquifers
occurs under both water-table and artesian conditions.

Unconsolidated Aquifers

The majority of the wells in the project area tap
aquifers in unconsolidated deposits (Appendixes A, C, and D)

in the stream valleys. These deposits are of Quaternary
age and consist mostly of boulders, cobbles, gravel, sand,
silt, and clay. They contain the only appreciable volume of
economically recoverable ground water in the Mora River
drainage system in western Mora County. The deposits range
in thickness from a few feet in tributary valleys and
canyons to more than 300 feet in the Mora Valley (figs. 9
and 10) (Mercer and Lappala, 1970). The thickness of these
materials is generally the result of erosional and deposi-
tional processes related to climatic and structural changes
in late Cenozoic time.

With one major exception, the depositional pattern
has followed the present east-southeastward-trending
drainage system. The exception is a major deposit of allu-
vium with associated terraces which occurs in a broad north-
trending valley extending from north of Black Lake in Colfax
County southward through Las Quebraditas Valley. The deposi-
tional agent appears to have been a large river that existed
in Pleistocene time and is believed to have drained the
entire eastern slope of the Sangre de Cristo Mountains. The
course of the river was controlled locally by Cenozoic fault
zones. Its flow was disrupted by headward erosion and stream
capture by eastward-flowing streams such as the Mora River.
Baltz and Read (1956, p. 71) refer to this river as the
ancestral Coyote River, named for Coyote Creek which, in its
upper reaches, flows in what is believed to be the ancestral
channel.

A probable sequence of events leading to the present
drainage system is shown in figure 11, which is a sketch of
the ancestral Coyote River drainage system showing lateral
attack and subsequent capture by the Mora River. A steeper
gradient on the Mora created by erosion of the softer sedi-
mentary rocks east of the ancestral Coyote probably acceler-
ated headward cutting and contributed to the forming of the
present drainage system.

The largest concentration of unconsolidated deposits
in the project area occurs in the Mora Valley near Mora and
appears to have resulted from alternating lake and river
channel deposition. The predominance of dark blue to black,
organic, varved clay found in test holes M-3, M-3a, and
M-5 (Appendix D) in this area indicates a swampy to lacus-
trine environment. The existence of sand and gravel lenses
in the clay indicates intermittent periods of river channel
deposition. The most probable sequence of events explaining
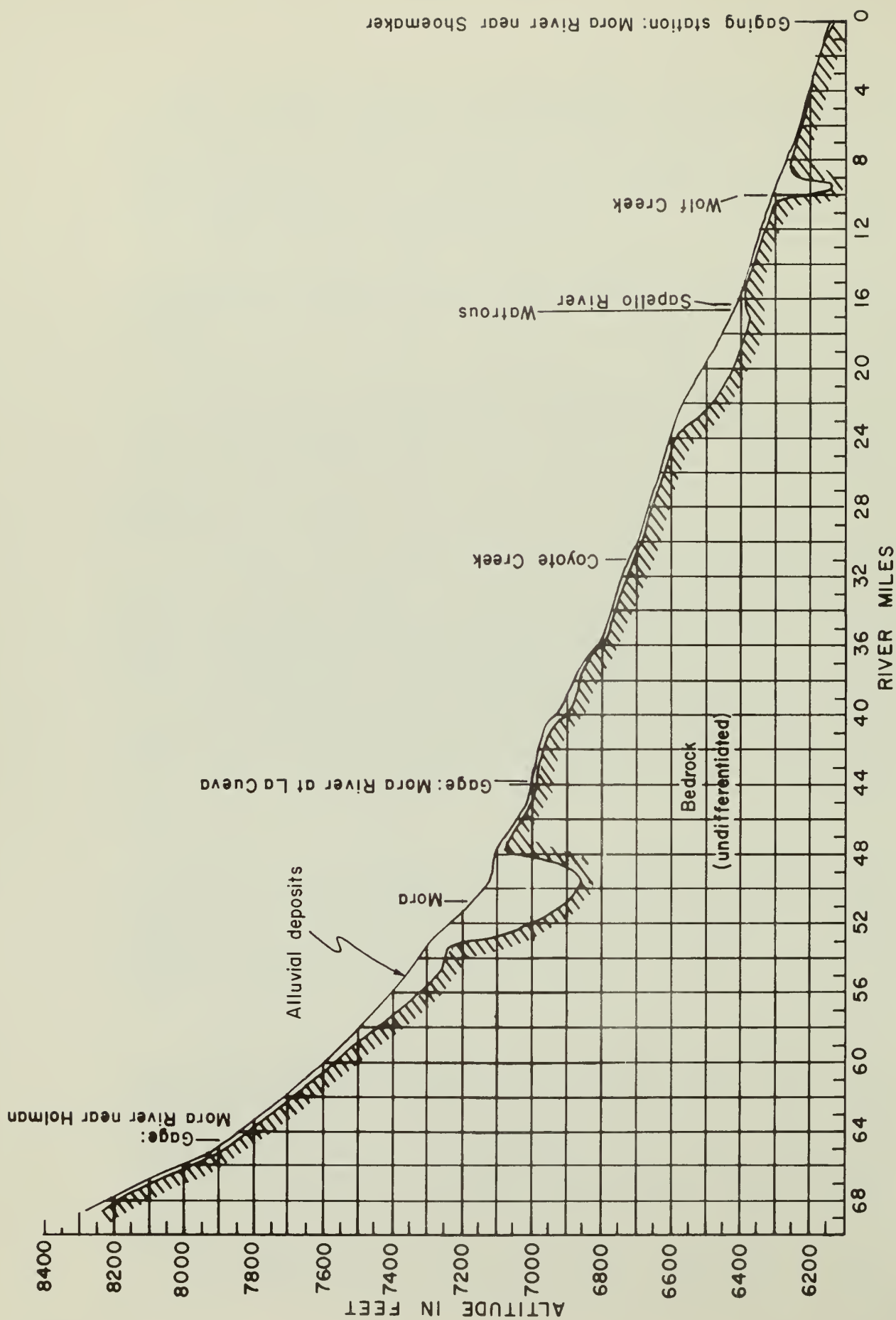
FIGURE 9.--Generalized longitudinal profile along the Mora River showing the thickness of alluvial deposits.

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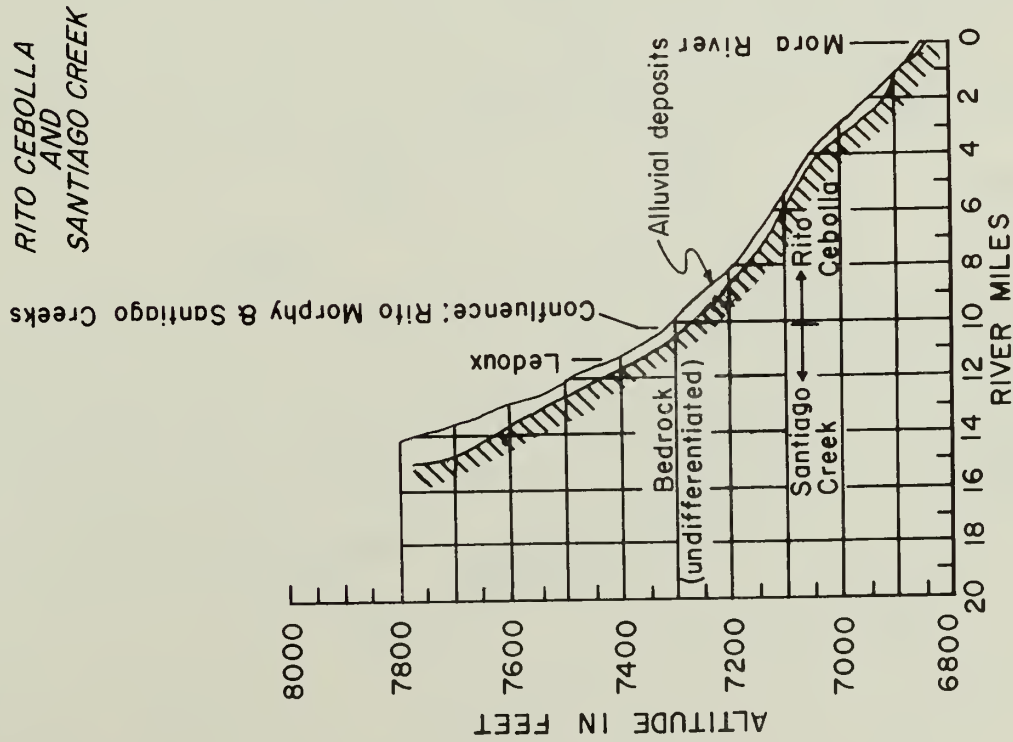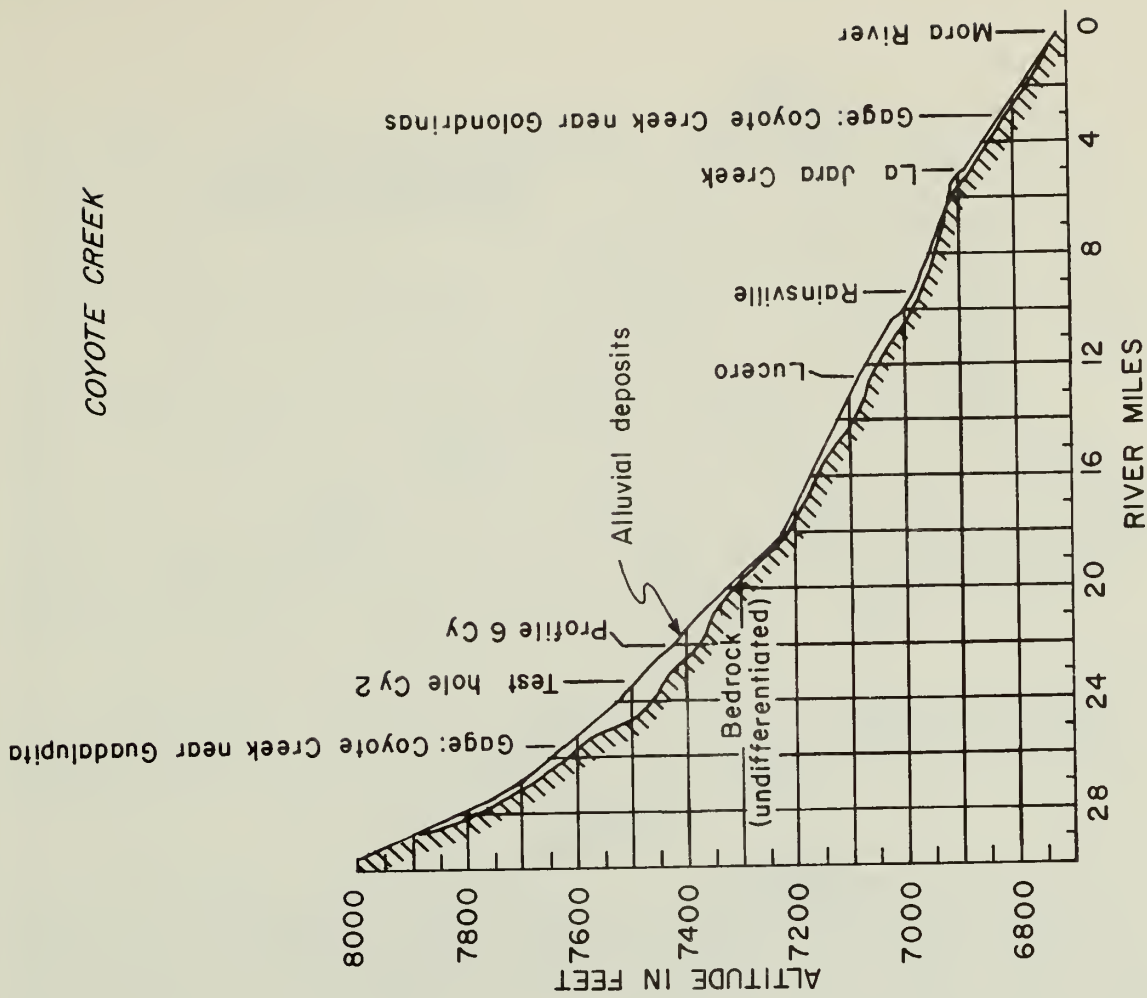
FIGURE 10.--Generalized longitudinal profiles along Rito Cebolla-Santiago Creek and Coyote Creek showing the thickness of alluvial deposits.
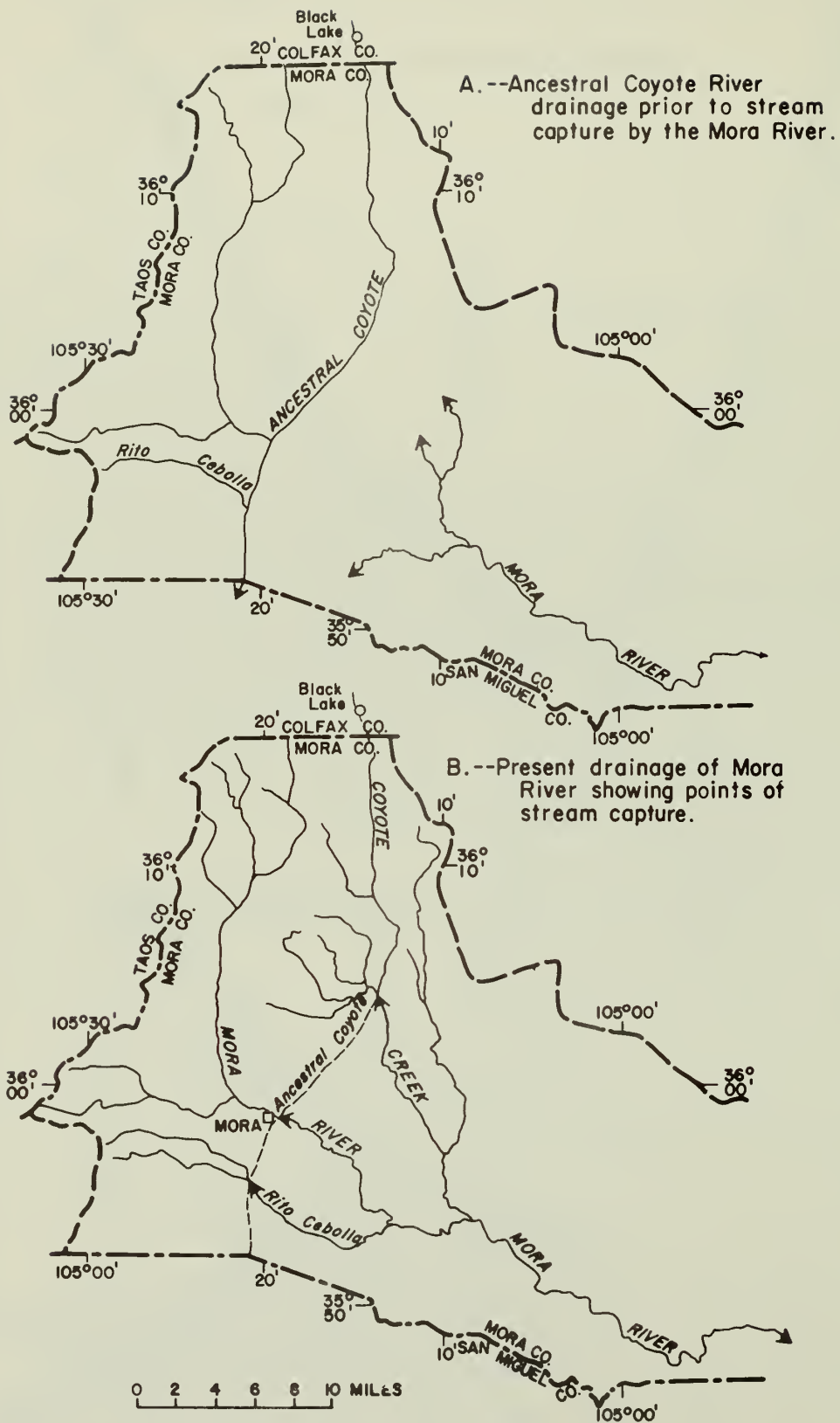
FIGURE 11.--Probable development of the present
drainage system in the Mora Valley.

these phenomena is the following: The ancestral Coyote
followed a southward course, and tributaries followed the
channels shown in figure 11. The area presently known as
the Mora Valley was a depression formed by downwarping and/
or faulting. Evidence for faulting was found in the sub-
surface during the seismic investigation (Mercer and Lappala,
1970). This depression represented a low-gradient reach of
the ancestral Coyote, most probably a meander valley, which,
when downwarping exceeded deposition, was occupied by a
lake. During this cycle the valley filled with organic
material interbedded with meander-type river deposits there-
by creating a poorly sorted mixture of organic and inorganic
clays, sands, and gravels with the clay fraction predomina-
ting. Results of test drilling indicate small lenses of
sand and gravel, alternating with clays.

Cenozoic faulting has also preserved alluvial deposits
in local areas. For example, this is the reason for the
thick section of alluvium above Watrous (pl. 1 and fig. 9).

Alluvial fan deposits are also present locally in
canyons tributary to the main drainage system. An example
of this type of deposit is located north of Guadalupita,
directly west of Coyote State Park. A water well (well 303A)
drilled near the edge of this fan penetrated approximately
200 feet of unconsolidated material (Appendix C). The small
recharge areas of these fans preclude the presence of large
supplies of ground water, however. The yield of the well
303A was less than 2 gpm.

Hydraulic Properties of Aquifers

Water that is pumped from wells moves to the well
through open spaces or pores in the rocks or unconsolidated
material. If the pores are large, numerous, and intercon-
nected much water can be pumped from a well; if the pores
are small, widely spaced, and poorly connected little water
can be recovered by pumping. The specific yield of a rock
is a measure of the ability of the pore space to yield water
to drainage by gravity. It is defined as the amount of water
yielded from storage per unit area of unconfined aquifer that
occurs as the result of a unit change in head. The specific
yield is equivalent to the storage coefficient in unconfined
aquifers. Generally, a specific yield of more than 20 percent
is considered high and a specific yield of less than 5 percent
is considered low.

Though a rock may have a large amount of pore space, it will not yield water to a well unless the water can readily move through the rock; if water can move, the rock is said to be permeable. A rock can be porous, but not permeable; it cannot be permeable without having interconnected porosity. Clay is one of the most porous of earth materials, but water cannot move through it easily because the water is bound tightly to the clay particles by forces of adhesion; the clay, therefore, is porous but only slightly permeable. The permeability of a rock is thus a measure of its capacity to transmit water.

A rock formation must have both porosity and permeability to be an aquifer, and the degree to which is has these properties determines in part whether or not it is a good aquifer. Also important is its areal extent and saturated thickness. For purposes of making mathematical analyses of the effects of pumping, the porosity and permeability of an aquifer must be quantitatively defined. Special terms have been given to these principal hydraulic properties. The term "transmissivity" refers to the ability of an aquifer to transmit water; the ability of an aquifer to store water is indicated by "storage coefficient." The storage coefficient and transmissivity can be used to determine the rate, magnitude, and extent of the lowering of the water level in an aquifer caused by a discharging well.

The storage coefficient (S) of an aquifer is defined as the volume of water which the aquifer releases from or takes into storage per unit surface area of the aquifer per unit change in component head normal to that surface.

Transmissivity (T) is the flow of water in cubic feet per day, at prevailing water temperature, through a vertical strip of aquifer one foot wide extending the full saturated height of the aquifer under a hydraulic gradient of 100 percent. Transmissivity is the product of the hydraulic conductivity and the saturated thickness of the aquifer, where hydraulic conductivity (measure of the material's capacity to transmit water) is defined as rate of flow of water at the prevailing kinematic viscosity through a cross section of 1 square foot (measured normal to the direction of flow) under a hydraulic gradient of 1 foot per foot, expressed in units of feet per day.

The specific capacity of a well is an important hydraulic property and is defined as the unit yield per unit of

drawdown of the water level in a well. It is usually ex-
pressed as gallons per minute per foot of drawdown during
a given time interval of pumping. For example, if the
water level draws down 5 feet at a pumping rate of 10 gpm,
the well has a specific capacity of 2. The specific capa-
city is not constant and commonly changes with changes in
pumping rates. The specific capacity will decrease with
time if steady pumping results in a continuing decline of
the pumping water level.

Field Tests of Aquifers

Two approaches were used to determine aquifer proper-
ties in the project area: 1) drilling, logging, and pumping
of test holes, and 2) pumping of existing wells. Thirteen
test holes were drilled in the alluvial deposits (Appendix
D); samples from eight test holes were analyzed for size
composition (Appendix E).

The transmissivity and storage coefficients of the
alluvium were obtained in various sections of the drainage
basin by aquifer tests. Pumping water from a well develops
a depression in the water table around the pumped well.
This depression gradually expands as pumping continues
unless withdrawal rates are balanced by either a decrease
in the natural discharge and/or an increase in recharge to
the aquifer. The difference between the pumping water level
and the water level before pumping is defined as the draw-
down. The drawdown in the well depends upon the pumping
rate, the time since pumping began, the transmissivity and
storage properties of the aquifer, and the well construction.
The area affected by pumping (area of influence) depends
upon the pumping rate, the time since pumping began, and the
transmissivity and storage properties of the aquifer. After
pumping is stopped, the water level in the well will even-
tually return almost to its original position. By pumping
a well at a known constant rate for a measured time, and by
recording drawdown during pumping and recovery after pumping,
enough data usually can be collected to compute the hydraulic
properties of the aquifer which, in conjunction with other
hydrogeologic data, can be used to predict long-term pumping
effects.

Pumping tests to determine aquifer characteristics
were conducted on all test holes except M-4, and on three
existing irrigation wells in the Watrous area. Also used
in analyses were data from pumping tests made by Turney and

Associates of Santa Fe (written commun.).

Attempts were made to determine drawdown rates when test holes M-1 and M-1a; M-3 and M-3a; M-5 and M-5a; and Cy-1 and Cy-1a were pumped; however, only tests on Cy-1 and Cy-1a yielded meaningful results. During the pumping period of test hole Cy-1, measurements of drawdown were made in test hole Cy-1a (observation well) and were plotted and analyzed by the Theis nonequilibrium method (fig. 12) as modified and applied by Ferris and others (1962, p. 92-93), to compute transmissivity and storage coefficient. Recovery measurements were made in test hole Cy-1 and plotted against the log of the ratio of time since pumping started to the time pumping stopped as shown in figure 12. The transmissivity values computed for this test are given in table 3. Well locations are shown on plate 2.

Pumping tests were made on three existing wells in the Watrous area (Appendix F, numbers 99, 100, and 102). Transmissivity was determined from these tests by the modified nonequilibrium method of Cooper and Jacob (1946, p. 526-534). An observation well (well 100) was available for use during the test of well 99; however, the storage coefficient could not be determined because the small changes in water level in the observation well were erratic and believed to have been caused primarily by evapotranspiration stresses rather than pumping. No observation wells were available for the tests of well 100 and 102, and consequently no storage coefficient could be computed from these tests. However, based upon examination of similar aquifer materials present in gravel pits in the Watrous area, a value of 0.2 is assumed to be a probable maximum value of the storage coefficient. Data plots for wells 99 and 102 are given in figures 13 and 14.

Data from pumping tests made by Turney and Associates of Santa Fe for the New Mexico Health and Social Services Department were used to compute transmissivity values for aquifers at four community supply wells in the upper reaches of the alluvial valleys (table 3).

Movement of Ground Water

Ground water is seldom stationary but moves under the force of gravity toward lower altitudes or toward a position of lower hydraulic head. Direction of movement down the hydraulic gradient is along paths that commonly are normal
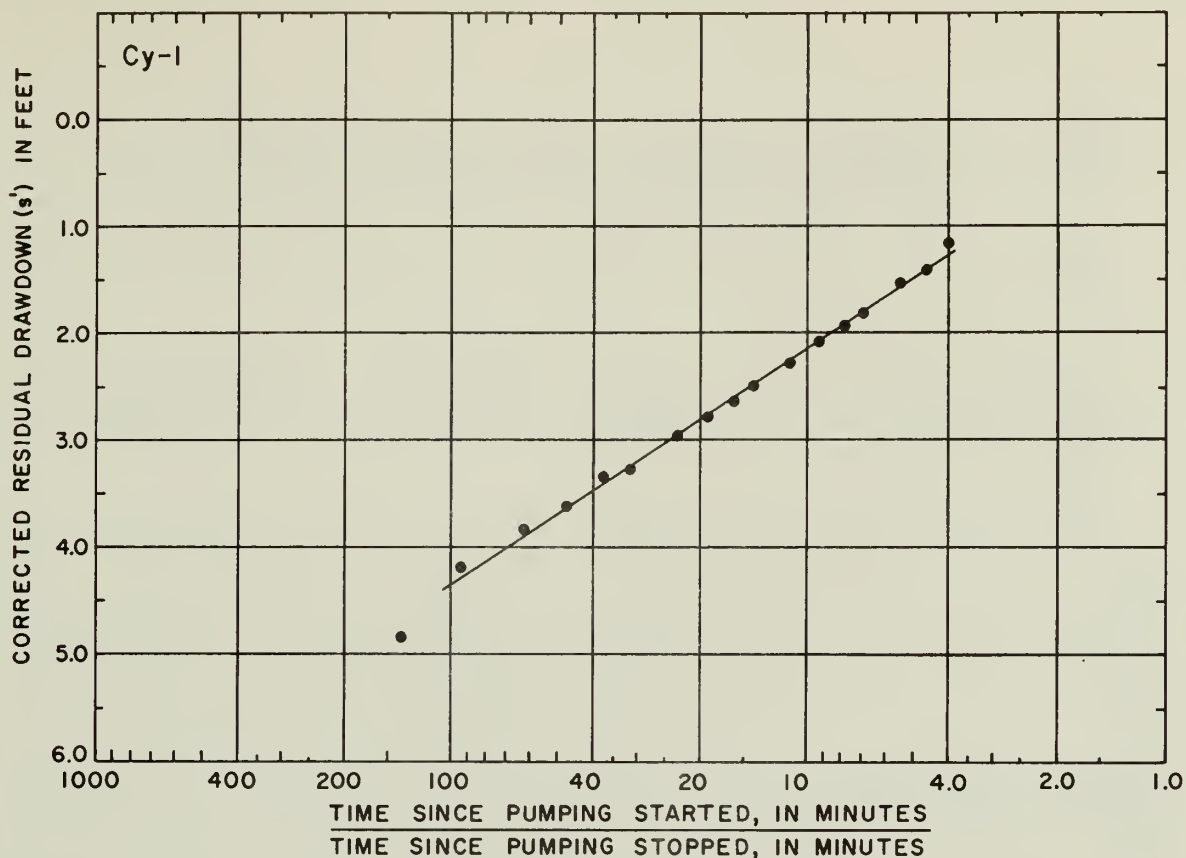
A.--Corrected residual drawdown of water level in test hole Cy-1 during recovery after pumping stopped.
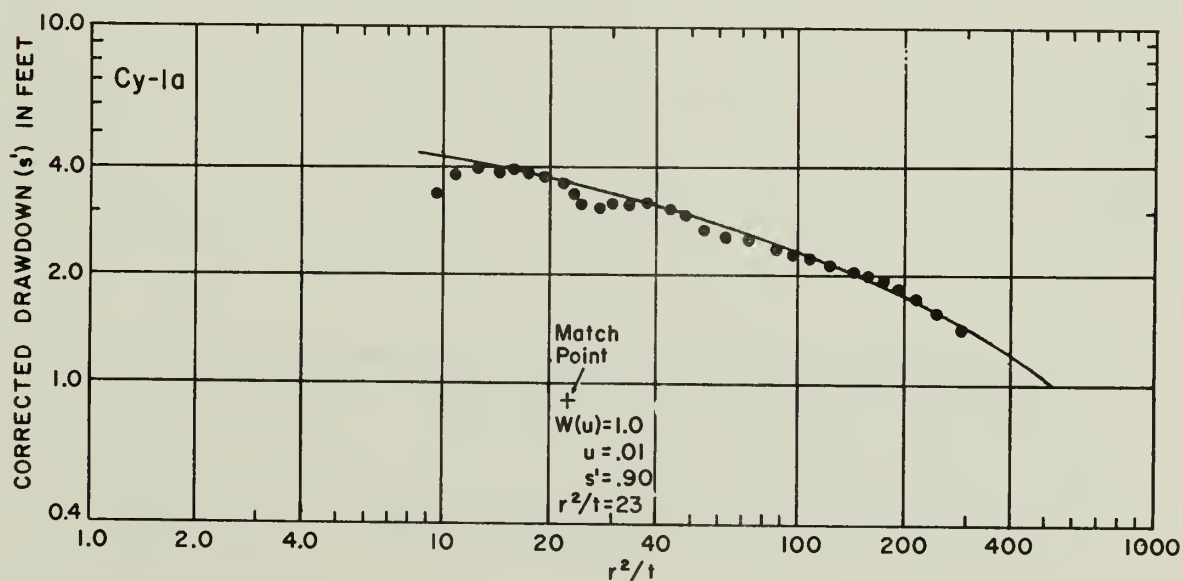
B.--Corrected drawdown of water level in test hole Cy-la during pumping cycle of test hole Cy-1.

FIGURE 12.--Corrected drawdown curves of water level in test holes Cy-1 and Cy-la. (Drawdowns corrected for saturated thickness by: $s' = s - s^2/2m$ where s = actual drawdown; s' = corrected drawdown; and m = standard thickness.)

TABLE 3.--Summary of aquifer properties determined from
pumping tests on wells and test holes in the
Mora River drainage, western Mora County, N. Mex.

Well or test hole number, and general location	Yield (gpm)	Specific capacity (gpm/ft)	Transmissivity (ft^2/day)
Watrous area			
99	940	61.0	20,000
100	450	33.7	3,900
102	220	25.7	3,400
Upper alluvial valleys			
Cy-1 and Cy-1a	2	0.36	40
151[1]	20	.30	13
152[1]	10	.56	20
211[1]	15	.10	13[2]
393[1]	25	.26	20

[1] Pumping tests made by Turney and Associates for New Mexico Health and Social Services Department. Exact locations of wells are not known.

[2] Transmissivities estimated from specific capacities by method described in Bentall (1963, p. 336-340).
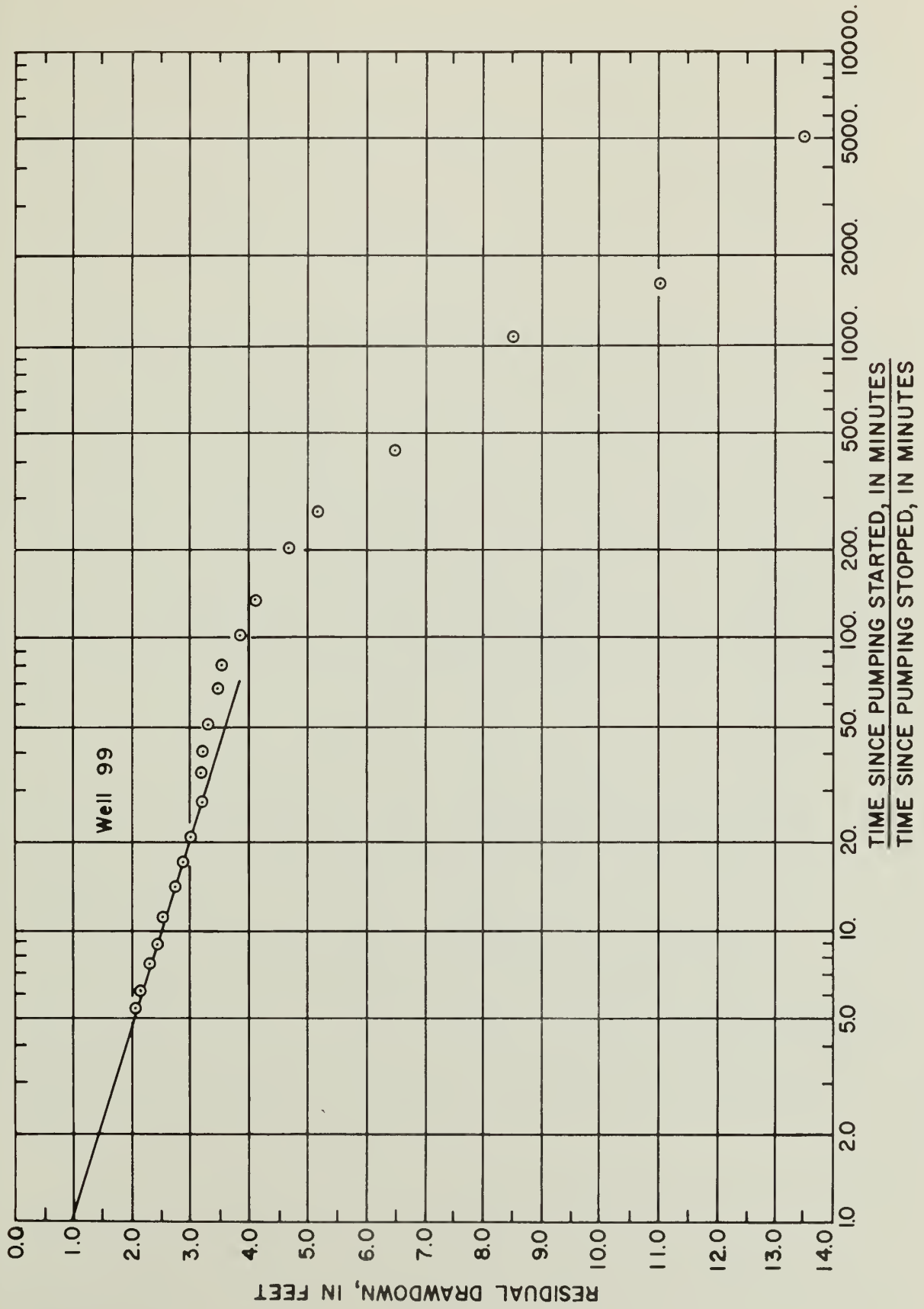
FIGURE 13.--Residual drawdown of water level in well 99 during recovery.
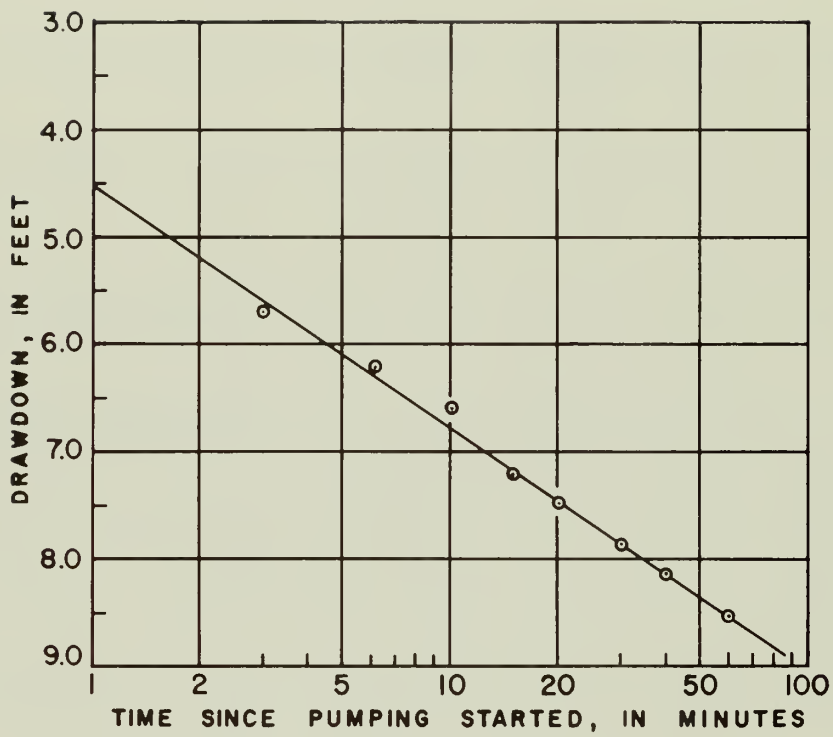
FIGURE 14.--Drawdown of water level
in well 102 during pumping.

to equipotential lines (contours on top of the saturated zone or the water table). The rates of ground-water movement generally are slow and usually range from a few inches to a few feet per day. Two factors determine the rate of movement: 1) the hydraulic gradient, or slope of the top of the zone of saturation (water table or potentiometric surface) of the aquifer, and 2) the hydraulic conductivity of the water-bearing materials. The quantity of water moving through the aquifer depends upon these factors and upon the cross-sectional area of the aquifer.

The slope of the water table and direction of movement of ground water in the alluvial aquifers were determined from a water-table contour map based on water-level measurements during the winter of 1968-69 in approximately 150 wells (pl. 2). Because many of the wells are in a narrow belt along the Mora River and its tributaries, much of the detail of the shape and slope of the water table could not be shown even in the contoured areas. The map showing contours on top of the saturated zone indicates that ground-water movement is generally toward the surface-drainage system. In the upper alluvial valleys of the project area, the slope of the water table is approximately 100 feet per mile; in the lower valleys it averages about 50 feet per mile.

Actual rates of movement are difficult to determine in most of the project area above Watrous because of the heterogeneity and anisotropy of the alluvial deposits. An estimated velocity based on limited data was calculated for the upper area. The hydrogeologic map (pl. 2) shows an average hydraulic gradient of about 100 feet per mile. Saturated thickness of the alluvium, exclusive of the Mora Valley near Mora, averages about 30 feet (Mercer and Lappala, 1970) and transmissivity determined from pumping tests ranges from 13 to 40 ft^2/day. Hydraulic conductivity is equal to transmissivity divided by saturated thickness. The estimated rate of movement calculated from the above figures and assuming an average porosity of 30 percent ranges from 0.03 to 0.1 ft/day.

In the vicinity of Watrous the deposits are relatively homogeneous and isotropic, making estimates of rates of movement more feasible. The water-level contours of wells in the area show that the hydraulic gradient ranges from 36 to 60 feet per mile. Saturated thickness of the alluvium ranges from 30 to 50 feet (Mercer and Lappala, 1970) and

transmissivities determined from pumping tests on wells 99, 100, and 102 (table 3) range from 3,400 ft^2/day to 20,000 ft^2/day. The probable rate of movement for this area calculated from the above figures and assuming a porosity of 35 percent ranges from 1 to 10 ft/day.

The rates of water movement can be used to compute travel times for contaminants entering the ground-water reservoir; however, actual migration of pollutants also depends upon factors other than the rate of water movement. Among these are the relationship between pore size in the aquifer and particle size of suspended solids, and the absorption characteristics of dissolved materials.

Volumes of ground water moving in the direction of the hydraulic gradient (underflow) were computed for the upper valleys, including the Mora Valley, and for the Watrous area. Underflow rates in the upper valleys average 60 ft^3/day. This is based on a transmissivity of 30 ft^2/day, a hydraulic gradient of 100 feet per mile, and an average cross sectional width of the valleys of 100 feet. For the Watrous area, the underflow is about 90,000 ft^3/day. This is based upon a transmissivity of 10,000 ft /day, a hydraulic gradient of 45 feet per mile, and an average cross-sectional width of the valley at the mouth of the canyon below Watrous of 1,000 feet.

Water-Level Fluctuation

The water table or potentiometric surface in an aquifer is not stationary but fluctuates in response to external changes. The amount and rate of the fluctuation is dependent on the rate of loss (discharge) or rate of replenishment (recharge) of water to ground-water storage. In this report, discharge means all outflows from the ground-water system, natural and artificial; recharge means all inflow to the ground-water system. Discharge of ground water from a discrete or local area of an aquifer will cause a lowering of the water level in that area unless it is equaled or exceeded by concurrent recharge. Discharge from the discrete area may result simply by water moving laterally into adjacent parts of the aquifer, by extraction of water by wells located in the particular area being considered, by evapotranspiration if water levels are near the land surface, by vertical leakage into higher or lower aquifers, or by outflow to artificial drains or streams that may cross the area under consideration. Recharge results from water moving

into the area laterally from adjacent areas or vertically
from higher or lower aquifers, from downward percolation of
precipitation or irrigation return flows that may occur in
the area considered, or infiltration of water from streams
and ditches which may cross the area. Water levels may rise
in some parts of an aquifer owing to the recharge-discharge
storage relationship and concurrently lower in other parts
of the same aquifer.

A record of periodic water-level fluctuations in an
aquifer furnishes valuable information about discharge,
recharge, and storage re' 'ionships of an aquifer. Monthly
fluctuations of water leve_s in the project area were
measured in 44 wells starting in March 1969 and continued
until November 1969 (Appendix G). Although measurements
were not extensive enough to establish long-term trends,
they do indicate seasonal fluctuations that probably are
representative of the area.

In the areas heavily irrigated with surface water the
water levels in the alluvium generally rose throughout the
irrigation season (June-September). For example, water
levels in test holes 131 and 135 (Appendix G) show a rise
of 1 and 2 feet, respectively. It should be pointed out
that in this particular area the only withdrawal from wells
is for domestic and stock use.

In the Watrous area some water is pumped from wells
for irrigation, but the discharge of these wells is exceeded
by recharge from surface irrigation resulting in a rise in
water levels during the irrigation season. For example,
well 90 (Appendix G) on the Phoenix Ranch near Watrous shows
a 3.3-foot rise during the irrigation season.

In the areas with less intensive irrigation, water
levels in the alluvial aquifers change very little, or show
a slight decline during the summer months. The water level
in well 11, near Chacon in the upper valleys, fluctuated
very little over the summer, and the water level in well 15,
in the same area, declined less than 2 feet (see Appendix G).

AREAS HAVING A POTENTIAL FOR GROUND-WATER DEVELOPMENT FOR IRRIGATION

Aquifers in areas considered for ground-water development for irrigation must be evaluated to determine if an adequate supply of water can be obtained and maintained. Criteria used in this evaluation are the following:

1. The saturated thickness of the aquifer must be sufficient to permit wells to be pumped at rates practical to supply water for the intended purpose.

2. The aquifer must be of large enough areal extent and have enough inflow to the area considered for ground-water development to sustain planned withdrawal rates over a long enough period of time to justify the development of the area.

3. If the first two criteria are met, spacing and location of wells must be such that:

   a. Interference between wells should be minimized within economic considerations.

   b. Optimum use be made of water from the entire stream-aquifer system.

The volume of ground water in storage in an alluvial aquifer can be estimated if the areal extent, the saturated thickness, and the average storage coefficient of the water-bearing alluvium are known. The average saturated thickness and areal extent of the aquifer in the project area were determined from seismic investigations (Mercer and Lappala, 1970). Estimates of the amount of ground water in storage in the alluvial aquifer in western Mora County are given in table 4.

Upper Alluvial Valleys

The ground water in storage in the principal upper tributary valleys of the Mora (Coyote Creek and Rito Cebolla) and in the main stem of the Mora River above Valmora (exclusive of Mora Valley) is estimated to be about 12,700 acre-feet (table 4).

TABLE 4.--Estimated amount of ground water in storage in the
alluvial aquifer, western Mora County, N. Mex.

Area or tributary 1/	Average saturated thickness (feet) 2/	Average storage coeffi- cient	Approxi- mate area of aquifer (acres)	Estimated storage (acre- feet)
Coyote Creek	35	0.05	3,000	5,200
Cebolla River (Rito Cebolla)	25	.05	2,100	2,600
Mora River above Valmora (Mora Valley not included)	30	.05	3,000	4,900
Subtotal				12,700
Mora Valley	200	.05	1,200	12,000
Near Watrous	40	.20	500	4,000
Valmora to Shoemaker Gage	35	.20	1,000	7,000
Subtotal				23,000
Total				35,700

1/ See figure 1.

2/ Determined primarily from seismic investigation (Mercer
and Lappala, 1970).

Figure 15 shows predicted drawdowns of water level that would occur in wells tapping alluvial aquifers in the upper valleys of the Mora River and its tributaries, and in the Watrous area. The predicted drawdowns were computed assuming a transmissivity of 40 ft^2/day and a storage coefficient of 0.05 for the upper valleys and a transmissivity of 4,000 ft^2/day and a storage coefficient of 0.20 for the Watrous area as determined from pumping tests (table 3).

The alluvial aquifers in the upper reaches of the Mora River drainage above Watrous fail to meet the criteria for ground-water development for irrigation mentioned previously. With the exception of the Mora Valley, average saturated thickness in the valleys is not over 35 feet which, considering the low transmissivity, is not sufficient to sustain well yields adequate for irrigation purposes or the excessive drawdowns expected to result from pumping for irrigation purposes.

The saturated alluvium in Mora Valley is known to average 200 feet in thickness and to exceed 300 feet in some places. It is possible that large yields of water could be obtained from wells in this area. If the deeper deposits have a high transmissivity and if adequate vertical leakage exists between upper beds and streams, a minimum of 12,000 acre-feet of water would be recoverable for development. Verification of this possibility must await drilling of a test well that full penetrates the alluvium.

Alluvial aquifers in the upper valleys are recharged primarily by perched streams, precipitation, seepage from surface irrigation canals, and seepage from poorly constructed drainage systems. The U.S. Bureau of Reclamation (1966, p. 56) estimates canal loss in the upper valleys to range between 30 and 37 percent of the total diverted flow.

In Mora Valley, at the mouth of Rio la Casa, a boulder fan of Quaternary age (table 1) is hydraulically connected to permeable deeply buried deposits that extend eastward at depths greater than 100 feet. Water from the Mora River, Rio la Casa, Canoncito, and Encinal Creeks recharges these deposits through the boulder fan. The following data support this conclusion:

1) Seepage investigations by the U.S. Geological Survey (1956, 1957, and 1961) show a significant reduction in flow from the Mora River as it crosses the boulder fan.
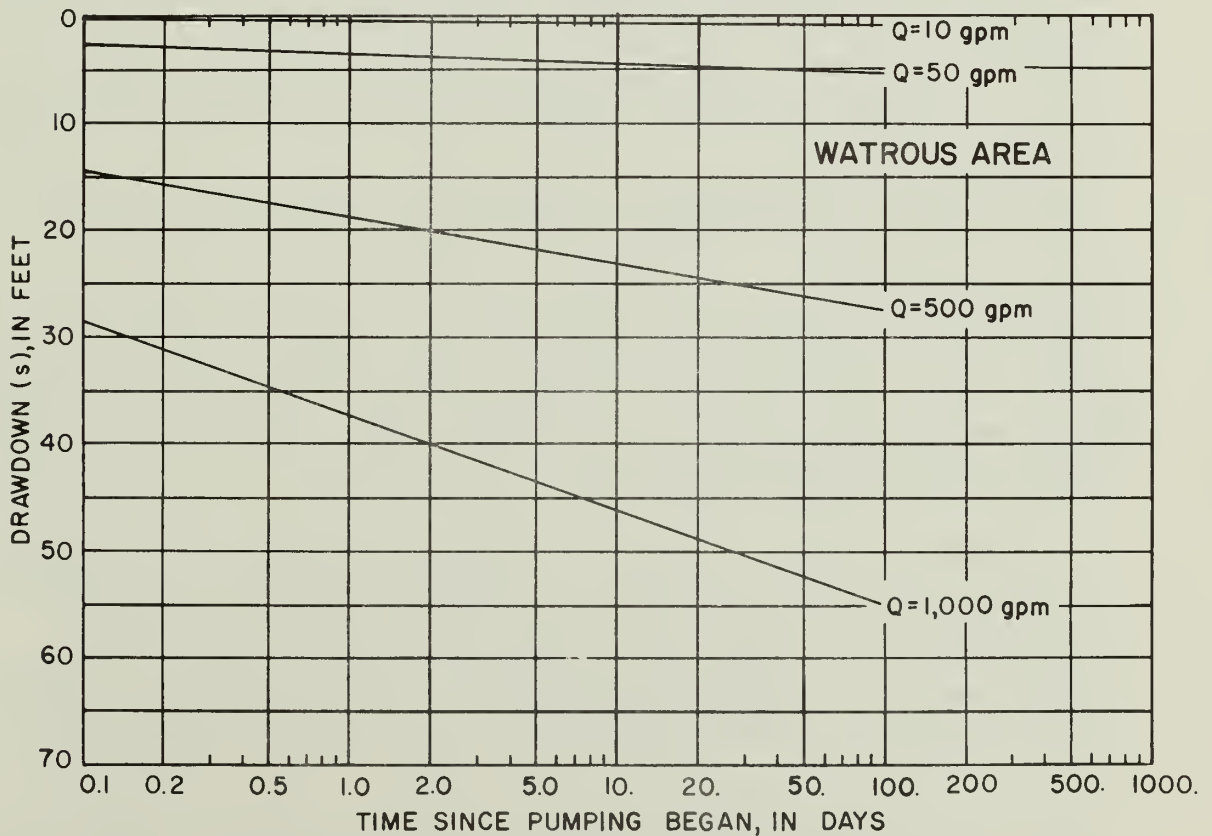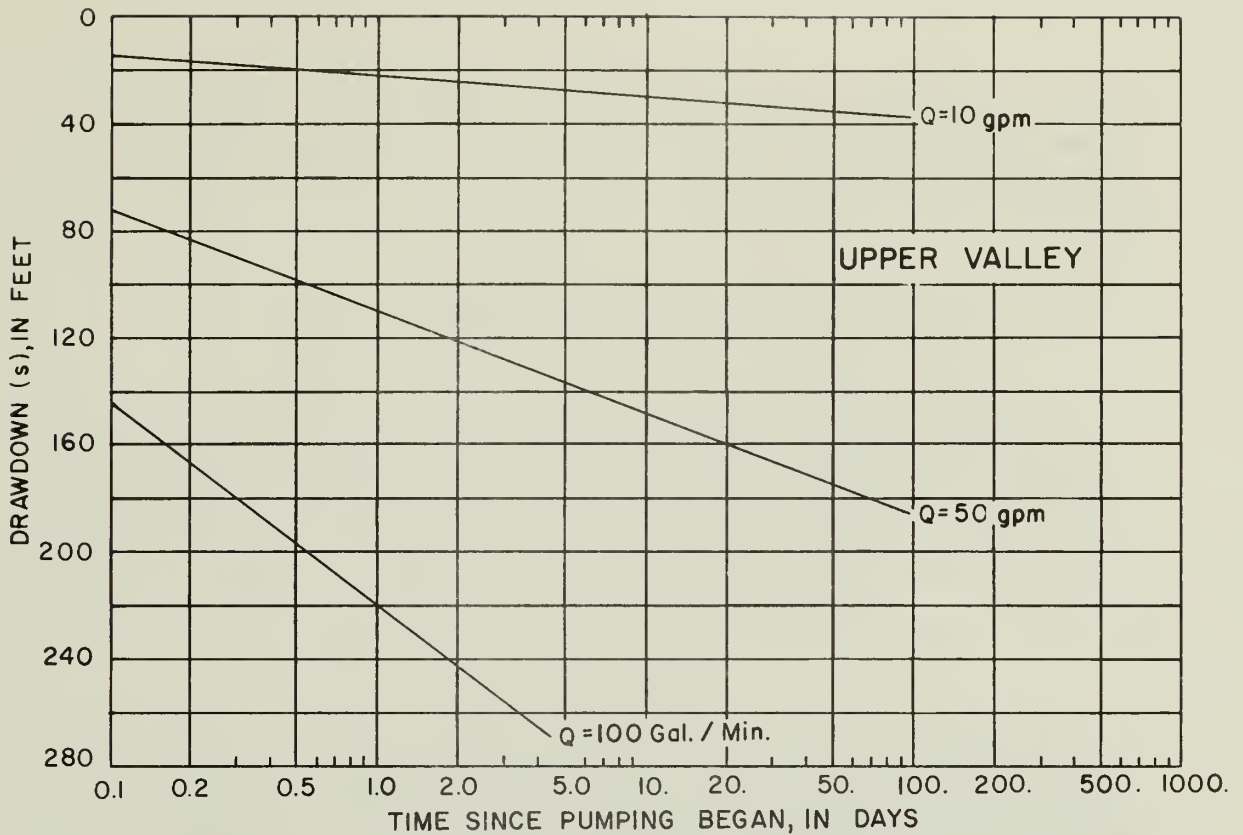
FIGURE 15.--Predicted drawdown of water levels in
hypothetical wells tapping alluvial aquifers
in the upper valleys of the Mora River and its
tributaries, and in the Watrous area, computed
for different pumping rates (Q).

2)   Sands and gravels are reported to depths of 100 feet in the Mora Community well (Appendix C, well 42). These deposits are reported to have yielded as much as 125 gpm with "no drawdown." No test of their full capacity is known to have been made.

3)   Water-level contours suggest continuity between the deeply buried deposits and the boulder fan.

Terrace and pediment deposits in the upper valleys are dependent upon precipitation and ephemeral streamflow for recharge. Some shallow dug wells in the Rainsville area, where these deposits may be less than 20 feet thick, are reported to go dry during years of below-average precipitation.

Watrous Area

Alluvial aquifers near Watrous generally meet the criteria for ground-water development for irrigation. Saturated thicknesses (as much as 60 feet) are great enough, when coupled with high transmissivities, to accommodate expected drawdowns during pumping at irrigation rates. Figure 15 shows drawdowns computed using a transmissivity of 4,000 ft^2/day, and a storage coefficient of 0.2. These figures are average values based upon three pumping tests (table 3) and examination of aquifer materials in gravel pits near Watrous. The higher storage coefficient of the aquifer in this area reflects well-sorted alluvial materials that originated in the drainage of the Sapello River, which joins the Mora River at Watrous. The higher carrying capacity of the Mora River below the confluence of the Sapello caused fine materials to be carried downstream, leaving the present coarse, well-sorted deposits.

Based on an average saturated thickness of 40 feet (Mercer and Lappala, 1970), a storage coefficient of 0.2, and an aquifer area of 500 acres, the volume of ground water in storage near Watrous would be about 4,000 acre-feet (table 4). Because the alluvial materials are coarse and well-sorted, more water per unit volume of aquifer material could be obtained from them than from alluvial material in the upper valleys. Data from aquifer tests on wells 99, 100, and 102 indicate that a potential exists for ground-water irrigation near Watrous. Although the alluvial aquifer meets the criteria for development, it is emphasized that careful consideration should be given to the location,

spacing, and construction of wells.

Alluvial deposits similar to those near Watrous are
present between Valmora and the gaging station below Shoe-
maker. The alluvium near Watrous fills a broad valley, but
between Valmora and the gaging station the alluvium occurs
in a narrow valley of the Mora River. The alluvial aquifer
in the valley has an average saturated thickness of 35 feet
(Mercer and Lappala, 1970), a storage coefficient of 0.2,
and an aquifer area of 1,000 acres. The estimated volume of
ground water in storage between Watrous and the gaging sta-
tion is about 7,000 acre-feet. However, development of
large supplies of ground water from wells in the narrow
valley may not be feasible as the cone of water-level de-
pression caused by pumping would soon reach impermeable
boundaries in the narrow valley which would cause a decrease
in the yield of wells.

Recharge to the alluvial aquifers in the Watrous area
is derived from precipitation inflow from perched streams,
return flow and tail-water losses from surface irrigation,
seepage from diversion canals and drainage ditches, and
outflow from bedrock aquifers. The U.S. Bureau of Reclama-
tion (1966, p. 56) estimates an average of 42 percent of
the diverted flow is lost through canal seepage.

WATERLOGGED LANDS AND RELATED PROBLEMS OF DRAINAGE

Land is said to be waterlogged if the moisture content
in the root zone is so great that it adversely affects crop
growth. Waterlogging results in accumulation of salts and
decreases aeration and workability of the soil; in addition,
waterlogged soils tend to warm more slowly during the spring,
retarting early germination of seed. This is an important
factor in western Mora County where the length of the grow-
ing season generally is less than 160 days (U.S. Bureau of
Reclamation, 1967, p. 39-46).

The primary area of waterlogged land is in the Mora
Valley near Mora. Here, rising water levels have rendered
the land useless for all crops except natural grasses and
alfalfa.

Factors contributing to waterlogging of soils in the
Mora Valley are the excessive use of surface water for
irrigation by upstream users and the textural and hydrologic
character of the material above the water table. Where

soils are tightly packed and composed of fine-grained mater-
ial, such as clay, the capillary fringe (zone in which ground
water is held by capillary forces) extends higher above the
water table than in areas where soils are looser and contain
coarser grained material. The clay soils also have lower
transmissive characteristics, which result in inadequate
subsurface drainage. Poor drainage coupled with the high
rate of recharge from excess irrigation or underflow from
upland areas has caused a rise in water levels throughout
the area and waterlogging of the land.

     Methods that could be used in the Mora watershed to
reduce or eliminate waterlogging include: canal and ditch
lining, modification and control of irrigation practices,
and construction of deep drains for lowering the water table.

     Canal or ditch seepage causes the principal loss of
water between the source and the delivery point of the water.
this not only reduces the volume of water available for
irrigation, but may also cause damage to land adjacent to
the canal or ditch. Delivery losses would be minimized by
lining the canals.

     Perhaps the foremost cause of waterlogging is excessive
use of water. Because surface water is plentiful during
winter months and early in the irrigation season, it is
wasted through uncontrolled flooding, continuous irrigation,
and excessively long irrigation runs which contribute greatly
to waterlogging.

     In parts of the area where waterlogged conditions are
caused by inadequate subsurface drainage, deep drains will
be required. Deep drains undoubtedly would be the most
effective corrective measure near Mora. Common methods for
achieving deep drainage are pumped wells, open ditches, and
buried-tile drains. Of the three, the buried-tile method
would probably be most feasible for use near Mora. Pumping
from wells is not recommended because of the hydrologic
characteristics of the soil and because a large number of
pumping plants would be required. Although initial cost
would be lowest, open ditches would not be suitable because
their construction would reduce the available agricultural
land and their maintenance would require continual attention.

     If deep drains were installed it would not only make
more tillable land available but might also increase the
amount of water available for irrigation. For example, if

the waterlogged land near Mora were drained to a depth of 3
feet the estimated volume of water initially salvaged would
be 90 acre-feet. This value is based on 600 acres of water-
logged land, an assumed storage coefficient of 0.05, and a
decrease in saturated thickness of 3 feet.

QUALITY OF WATER

Although terms used in this report are common ones,
some have limited usage and others may convey a variety of
meanings. To aid in clarity, some of the terms used are
defined below:

Definition of terms

milligrams per liter (mg/l) - A unit expressing the
concentration of chemical constituents as the weight
of solute in milligrams per liter of solution. In
water of low mineral concentration, milligrams per
liter is approximately equal to grams of constituent
per million grams of solution, commonly reported as
parts per million (ppm)

specific conductance - A measure of the ability of
water to conduct an electric current; expressed in
micromhos per centimeter at 25°C. Because specific
conductance is dependent upon the concentration
of ions in solution, it can be used as an approxi-
mate measure of the degree of mineralization of
water.

sodium-absorption-ratio (SAR) - A measure of the
quality of irrigation water related to the absorp-
tion of sodium by soil from applied water. The
ratio is determined by dividing the concentration
of sodium by the square root of one-half the con-
centration of calcium plus magnesium, all concen-
trations expressed as milliequivalents per liter.
In reported ratios, the higher the figure, the
poorer the quality of water for irrigation.

hardness - A property of water that results in the
formation of soap scum. Several chemical constitu-
ents cause hardness, but the degree of hardness for
most water can be estimated from the concentration
of alkaline earths, such as calcium and magnesium.
The U.S. Geological Survey uses adjective ratings to

describe hardness attributed to $CaCO_3$. Thus, soft water contains 0-60 mg/l: moderately hard, 61-120 mg/l; hard, 121-180 mg/l; and very hard, more than 180 mg/l.

Significance of Chemical Constituents

Water samples from surface and ground-water sources in western Mora County were analyzed to determine the concentration of chemical constituents that affect the usability of the water. The results of these analyses are compared with recommended limits for selected uses, and the derivation and significance of constituents or properties of the water are summarized in table 5. Characteristics of the water such as pH and specific conductance were also determined. Derivation, significance, and recommended limits are those recommended by the California State Water Pollution Control Board (1957).

One of the factors that determines the success or failure of an irrigation project is the quality of the water applied. The suitability of water for irrigation is determined by the total salt concentration, the concentration ratios of different salts, the increase of salt concentration and chemical reactions in the soil after water application, and the concentration of trace elements such as boron. Irrigation practices also are important. Application of water that is rated as good may, with poor irrigation practices such as inadequate provision for drainage, cause deterioration and eventual destruction of the productive capacity of the soil.

Boron, sodium, and salinity are the principal hazards related to the chemical character of irrigation water. Boron is necessary in very small quantities for normal growth of all plants, but in larger concentrations it is toxic. Quantities needed vary with the crop type; sensitive crops require minimum amounts and tolerant crops will not be affected by several times these concentrations. Among the plants most sensitive are citrus fruit and walnut trees; truck garden crops such as carrots, lettuce, and cabbage are among the most tolerant.

When the sodium concentration in applied water is high compared to calcium and magnesium, sodium replaces calcium and magnesium in the soil and a sodium (alkali) soil develops. Sodium soils may be improved by adding conditioners

TABLE 5.--Common chemical constituents, characteristics of water, and summary of analyses of water, western Mora County, N. Mex.

Constituent or property	Derivation	Significance	Recommended limits for selected users	Range in concentration for samples analyzed (mg/l)
Silica (SiO_2)	Siliceous materials present in virtually all rocks.	Forms hard scale in boilers and pipes. Inhibits deterioration of zeolite-type water softeners. May prevent corrosion in pipes by forming a protective coating.	1 mg/l for high-pressure-boiler feed. 10 to 50 mg/l for other industrial processes.	2.8- 56
Iron (Fe)	Iron-bearing minerals present in most rocks. Iron may be added to water in contact with iron objects such as well casing, pipes, and storage tanks.	Oxidizes to a reddish-brown precipitate. More than about 0.3 mg/l stains laundry and utensils. Objectionable for many industrial, food processing, and beverage uses. Supports growth of certain bacteria. Imparts objectionable taste when greater than about 1.0 mg/l.	Less than 1.0 mg/l for most industrial use. 0.3 mg/l for the sum of iron and manganese in domestic supplies.	0 - 1.8
Calcium (Ca)	Limestone, dolomite, gypsum or gypsiferous shale, sewage, and industrial waste.	With magnesium causes most of the hardness and scale-forming properties of water. Beneficial in irrigation water where unfavorable sodium ratio exists in soil.	5 mg/l for boiler feed.	4.6- 461
Magnesium (Mg)	Dolomite and most igneous rocks.	Similar to calcium in flocculating soil colloids, imparting the property of hardness, and forming scale. Salts of magnesium act as cathartics.	125 mg/l for drinking and culinary waters.	0.2- 53
Sodium (Na) plus potassium (K)	Feldspars, salt beds, other common minerals, sewage, and industrial wastes.	Causes foaming in boilers when concentration of sodium plus potassium exceeds 50 mg/l. High concentrations are toxic to plants, harmful to soil, and will act as cathartic. High ratio of sodium to calcium plus magnesium is harmful to soil structure.	50 mg/l of sodium plus potassium for boiler water. 115 mg/l sodium maximum for domestic use.	10.6- 181.6
Bicarbonate (HCO_3) and carbonate (CO_3)	Carbonate rocks and calcareous materials.	In combination with calcium and magnesium forms scale and releases corrosive carbon dioxide gas. A high ratio of carbonate and bicarbonate to alkaline earths may cause the water to be unsuitable for irrigation.	100 mg/l for boiler use.	87 - 596
Boron	Granitic rocks and permatites	Boron is necessary in small quantities for normal growth of plants, but very detrimental in large quantities.	Above 0.5 mg/l citrus fruits affected. If over 2.0 mg/l, most crops injured.	.01 .53
Sulfate (SO_4)	Gypsum, anhydrite, pyrite, and oxidized organic matter in the sulfur cycle.	In combination with calcium and magnesium forms hard scale. As magnesium or sodium sulfate acts as a cathartic. High concentrations may be toxic to plants.	250 mg/l for domestic use. 250 mg/l in carbonated beverages.	6.4-1,080
Chloride (Cl)	Most rocks and soils, sewage, and industrial effluents.	High concentrations of chloride salts impart salty taste. May be toxic to plants. May accelerate corrosion in pipes.	250 mg/l for domestic use. 200 mg/l for kraft paper pulp.	0.6- 83
Fluoride (F)	Fluorite, apatite, and hydrothermal solutions.	Reduces incidence of tooth decay in children when concentration is 0.5 to 1.5 mg/l; more than about 1.5 mg/l causes mottling of tooth enamel in children. Concentrations of more than 5 mg/l may cause fluorosis.	1.5 mg/l for domestic use. 1.0 mg/l for food canning.	0.2- 17
Nitrate (NO_3)	Decayed organic matter, sewage, nitrate fertilizers, and nitrates in the soil.	Values higher than 5 to 10 mg/l may suggest pollution. More than about 44 mg/l may cause methemoglobinemia (infant cyanosis). Generally nitrate in water used for irrigation is desirable for its fertilizing value.	44 mg/l for domestic use.	0 - 119
Dissolved solids	Rocks, soils, industrial and sewage effluents.	High concentrations are harmful to plant and animal life and can cause foaming in boilers.	1,000 mg/l for domestic use, although more saline waters are used by some communities without harmful effects. 1,000 mg/l for most industrial uses.	121 -1,810
Hardness (as $CaCO_3$)	Mainly calcium and magnesium in solution; certain other cations cause hardness but are ordinarily present in small amounts.	Hard water causes excessive soap consumption, scale in boilers and pipes, toughening of cooked vegetables. Tends to prevent corrosion of metals. Produces finer grained structure in baking. Very hard water retards fermentation.	Water having a hardness of more than 121 mg/l generally considered to be hard. 0 to 50 mg/l for laundering. 80 mg/l for boiler feed water at 0 to 150 pounds per square inch.	22 -2,194
Specific conductance (micromhos at 25°C)	Ion concentration in water.	An increase in value indicates an increase in dissolved solids.	More than 1,500 generally exceeds standards for domestic water. More than 3,000 unsuitable for irrigation under most conditions.	180 -2,090
pH (hydrogen-ion concentration expressed as pH)	Hydrogen-ion concentration.	Values from 1 to 7 indicate decreasing acidity; of more than 7 indicate increasing alkalinity. Affects taste, corrosivity, and treatment processes such as coagulation. Low value desirable where irrigation water applied to alkaline soils.	7.5 for food canning and freezing. More than than 9.0 unsuitable for irrigation use.	6.8 8.8

such as gypsum, which replenish calcium and magnesium.

Salinity (dissolved solids) increases the osmotic pressure in the soil solution, and when salinity is high, plant growth is retarded. Because the salinity of water is closely related to the specific conductance of water, specific conductance may be used as a measure of the salinity hazard of water.

Water Quality in the Mora River Drainage

Chemical analyses of 24 samples of water from wells, 2 samples from springs, and 4 samples of surface water are given in Appendix H. Specific conductance values of water from many wells are also given in Appendix A.

The analyses show only the chemical characteristics of the water. Because the analyses do not include any determination of the biological material contained in the water, they do not indicate sanitary conditions.

Ground Water

Most of the analyses of ground water are of water samples collected from wells and springs that produce from the alluvium. The dissolved-solids concentration of the 19 samples ranged from 121 to 537 mg/l. Ground water in the alluvium is generally hard to very hard and, based on a percentage composition, may be roughly classed as a calcium sodium sulfate bicarbonate type water.

Water from the bedrock aquifers generally contains more dissolved solids than water from the alluvium. Dissolved-solids concentrations range from 329 to 1,810 mg/l in the seven samples analyzed.

Concentrations of some constituents in water from several wells tapping the alluvium exceed the U.S. Public Health Service (1962) standards. Anomalous high values of fluorides were found in wells 11, 54A, 57, and 212. The concentration of fluoride in well 57 near El Alto was 17 mg/l, the highest recorded in the area and about 11 times the maximum recommended (table 5). Nitrate concentrations are under the recommended limits in all alluvial wells; however, it is extremely high, 119 mg/l, in well 220 which taps both the alluvium and the Sandia Formation of Pennsyl-

vanian age. This high value indicates probable contamination
from some outside source. High iron content (1.8 mg/l) was
found only in well 11. Sulfate is above recommended limits
in 20 of the 26 samples collected from wells and springs.

Ground water in western Mora County appears to be well
suited for irrigation. The salinity and sodium hazard,
plotted as open circles in figure 16, ranges from a low- to
medium-sodium hazard to a low- to high-salinity hazard.

Surface Water

The chemical quality of surface water based on water
analyses made for this study is generally acceptable for
all uses and meets the U.S. Public Health (1962) standards.
The biological quality was not measured and its suitability
for human use was not evaluated.

River water is uniform in chemical character through-
out the study area. It is ge. rally of the bicarbonate type,
and is very hard with dissolved-solids concentrations rang-
ing from 244 to 296 mg/l. The surface water is suitable
for irrigation; as indicated by figure 16, it falls in the
medium-salinity and low-sodium hazard category.

SUMMARY

Preliminary reconnaissance indicated that unconsolidated
deposits were the most likely source of sufficient ground
water to supplement surface-water supplies during low-flow
periods. Deposits of alluvial, colluvial, lacustrine, and
glacial(?) origin contain ground water in the valleys of
nearly all of the Mora River drainage within western Mora
County, New Mexico. Exceptions are isolated terrace and
pediment deposits in the Rainsville area.

Thickresses of unconsolidated deposits (determined by
seismic rerraction) are generally the result of climatic and
structural changes in late Cenozoic time and range from a
few feet in tributary valleys to more than 300 feet in the
Mora Valley.

Results of test drilling, examination of driller's
logs, and pumping tests showed that the unconsolidated
boulders, cobbles, gravel, sand, silt, and clay filling
the valleys above Watrous are very heterogeneous and aniso-
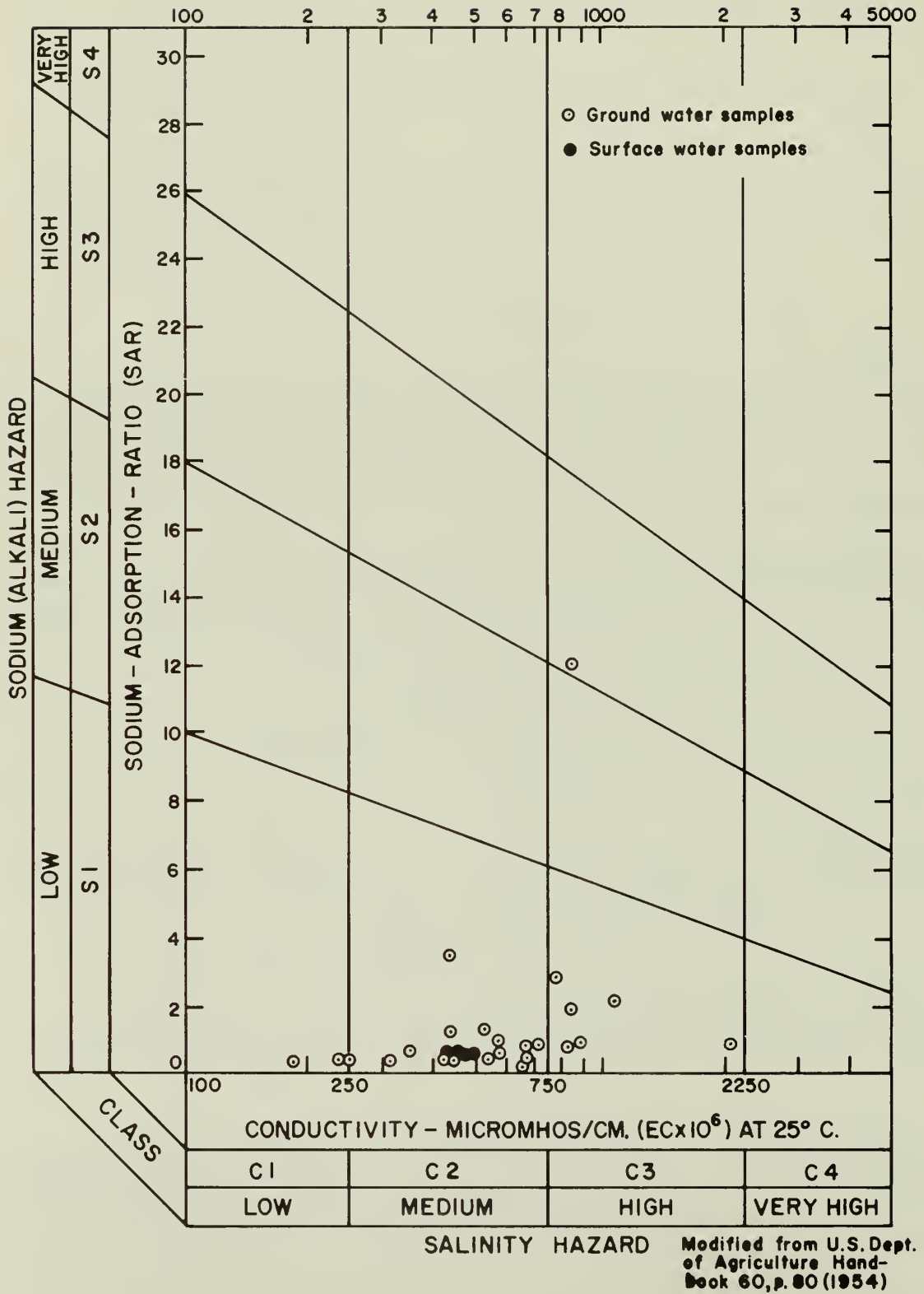
FIGURE 16.--Sodium-salinity hazard for samples of ground
and surface water in the Mora River drainage basin.

tropic. Aquifer tests indicate that the maximum transmissivity and storage coefficient for these areas are 40 ft^2/day and 0.05, respectively; however, the reported performance of some existing wells suggests transmissivity may be higher locally. Even though the total storage of ground water in the upper valleys (exclusive of Mora Valley) is about 12,700 acre-feet it is doubtful if an adequate supply could be maintained at pumping rates sufficient to supply supplemental irrigation wells.

Potential aquifers in the alluvial deposits in Mora Valley have been explored only to a depth of about 100 feet. If the deeper deposits could yield adequate supplies for irrigation there would be a minimum of 12,000 acre-feet of water than could be developed for irrigation. Ability of the deeper deposits to yield large quantities of water could be determined by drilling and pumping a test well that fully penetrates the alluvial aquifer.

Additional ground-water development appears to be feasible in the alluvial valley near Watrous. Results of test drilling, examination of gravel pits, and pumping tests in this area showed that unconsolidated deposits are relatively homogeneous and isotropic. Transmissivities range from 3,400 to 20,000 ft^2/day, and the assumed maximum storage coefficient is 0.20. The amount of ground water in storage is about 4,000 acre-feet. This, in conjunction with the high transmissivity, indicates that at pumping rates normally associated with irrigation wells, the supply would be sustained.

The quality of both ground-water and surface-water supplies throughout the project area meets established criteria for irrigation use.

In general, the possibilities for additional ground-water development to supplement present surface-water supplies for irrigation is limited.

The basic cause of present shortages appears to be inefficient use of surface supplies and delivery systems. If shortages still exist after surface supplies have been utilized to their maximum efficiency, and a decision to reclaim waterlogged lands has been made, the development of additional water supplies would require studies to: 1) determine water-bearing and transmissive properties of alluvial deposits at depths greater than 100 feet in the

Mora Valley by test drilling and pumping tests, 2) determine
the degree of hydraulic continuity between boulder fan
materials at the mouth of Rio la Casa and materials deeper
than 100 feet in the Mora Valley, and determine whether the
boulder fan could be utilized as a recharge area, 3) deter-
mine the full extent of the saturated material in the valley
near Watrous by intensive seismic refraction studies, and
4) examine the bedrock aquifers, primarily the Santa Rosa
Sandstone of Triassic age and the Dakota Sandstone of
Cretaceous age, as possible supplemental sources of irriga-
tion-water supplies.

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APPENDIXES

Appendix A.--Records of selected wells in the Mora River drainage, western Mora County, N. Mex.

EXPLANATION:

Well No.: Wells numbered 1 through 199 are located in the drainage of the main stem of the Mora River; wells numbered 200 through 299 are located in the drainage of Rito Cebolla; wells numbered 300 through 399 are located in the drainage of Coyote Creek; wells numbered 400 through 499 are located in the drainage of the Sapello River.

Latitude and longitude: Interpolated from 7½-minute USGS topographic quadrangle maps.

Owner or name: MDWCA; Mutual Domestic Water Consumers Association.

Depth: R, reported; otherwise measured.

Diameter: Diameter of casing or diameter of hole, if uncased.

Altitude: Altitude of land surface at well. Interpolated from 7½-minute USGS topographic quadrangle maps.

Depth to water: Measured depths given to nearest one-tenth foot; reported depths given to nearest foot.

Principal aquifer: Qal, alluvium; QTb; basalt; ℞sr , Santa Rosa Sandstone; ℞u , Pennsylvanian rocks, undivided.

Use: D, domestic; I, industrial; Irr, irrigation; O, observation; PS, public supply; S, stock; U, unused.

Specific conductance: Field measurements with portable meter. Asterisk (*) indicates chemical analysis in Appendix H.

Log: X indicates driller's log listed in Appendix C.

Yield: All yields are those determined by bailing unless otherwise indicated; e indicates estimated yield; sc indicates specific capacity, in gpm/ft.

Well No.	Latitude	Longitude	Date completed	Owner or name	Depth (feet)	Diameter (inches)	Altitude (feet)	Water level			Principal aquifer	Use	Specific conductance (micromhos at 25°C)	Log	Temperature (°C)	Yield (gpm)
								Depth to water (feet)	Date	Altitude (feet)						
1	36°11'35"	105°21'01"	1968	--	27R	8	8,540	--	--	--	Qal	D	580	--	9	--
2	36°09'19"	105°20'52"	--	--	--	36	8,180	7.3	11-12-68	8,173	Qal	D	--	--	--	--
3	36°09'15"	105°21'06"	1965	F. Vasquez	65R	--	8,260	--	--	--	--	--	--	--	--	4
4	36°08'38"	105°22'00"	--	Old School	35	72	8,140	25.4	11-12-68	8,115	Qal	PS,O,U	--	--	--	--
5	36°08'29"	105°22'16"	1967	S. Maestas	125R	6	8,150	--	--	--	--	D	--	X	--	6
6	36°08'34"	105°21'59"	1967	J. Bernal	120R	6	8,120	7.0	1-30-67	8,113	Qal(?)	D	--	X	--	20
7	36°07'58"	105°22'08"	1964	E. L. Duran	180R	--	8,020	--	--	--	--	D	--	X	--	10
8	36°07'54"	105°22'05"	1962	L. Ortega Jr.	90R	--	8,010	--	--	--	--	D	--	X	--	3
9	36°07'44"	105°21'48"	1962	P. Abeyta	126R	6	7,990	18.6	11-12-68	7,971	--	D	--	X	--	40
10	36°08'52"	105°22'53"	1961	D. Martinez	116R	6	8,340	--	--	--	--	D	--	X	--	--
11	36°06'58"	105°22'27"	1968	W. Romero	50	6	7,900	7.0	11-12-68	7,893	℞yu	D,U,O	1,500*	--	--	4
12	36°06'53"	105°22'39"	1961	J. Trujillo	50R	6	7,890	--	--	--	Oal(?)	D	--	X	--	7
13	36°06'49"	105°22'35"	--	--	10	36	7,870	4.6	11-12-68	7,865	Qal	D	900	--	10	--
14	36°05'09"	105°22'39"	1967	E. Lovato	76R	8	7,760	20	5-18-67	7,740	--	D	--	X	--	60+
15	36°05'05"	105°22'37"	--	do.	23	24	7,750	13.3	11-12-68	7,737	Qal	D,O	780*	--	12	--
16	36°04'21"	105°22'51"	1964	N. Armijo	125R	6	7,690	30.8	11-12-68	7,659	--	D	--	X	9	--
17	36°03'37"	105°22'54"	--	E. Cruz	40R	36	7,660	19.0	11-12-68	7,641	Qal	D	1,500	--	10	--
18	36°02'48"	105°23'08"	1964	C. A. Grandorf	105R	6	7,630	--	--	--	--	D	1,000	X	--	16
19	36°02'48"	105°23'05"	--	P. Romero	--	6	7,610	36.4	11-12-68	7,574	Oal	D	760	--	11	--
20	36°02'37"	105°23'04"	1957	R. R. Valdez	50R	6,8	7,580	--	--	--	Qal	D	--	X	--	25

Appendix A.--Records of selected wells in the Mora River drainage, western Mora County, N. Mex. - Continued

Well No.	Latitude	Longitude	Date completed	Owner or name	Depth (feet)	Diameter (inches)	Altitude (feet)	Water level Depth to water (feet)	Water level Date	Water level Altitude (feet)	Principal aquifer	Use	Specific conductance (micromhos at 25°C)	Log	Temperature (°C)	Yield (gpm)
21	36°02'13"	105°22'53"	--	F. A. Duran	37R	30	7,530	30.7	11-12-68	7,499	Qal	D	720	--	12	--
22	36°01'59"	105°22'33"	1965	A. Sanchez	100R	6	7,520	--	--	--	--	D	--	X	--	3
23	36°01'52"	105°22'40"	1954	E. Hurtado	50R	6	7,490	29.0	11-12-68	7,471	Qal	D	610	X	16	20
24	36°01'39"	105°22'57"	1956	N. Mex. Dept. Public Health	150R	6,10	7,520	--	--	--	--	D	--	X	--	25
25	36°01'17"	105°22'52"	1967	W. Garcia	144R	6	7,550	90	2-14-67	7,460	--	D	--	X	--	12.5
26	36°01'05"	105°22'50"	1964	E. Chacon	62R	6	7,490	--	--	--	--	D	--	X	--	25
27	36°00'58"	105°23'21"	1957	J. or Romero	82R	5	7,560	--	--	--	--	D	--	X	--	20
28	36°00'42"	105°23'25"	1964	S. Romero	90R	--	7,530	--	--	--	--	D	--	X	--	6
29	36°00'22"	105°23'37"	--	J. Bonney	55R	6	7,500	26.9	11-13-68	7,473	--	D	610	--	13	--
30	36°00'07"	105°23'30"	--	--	--	48	7,540	45.4	11-13-68	7,495	Qal	D	900	--	10	--
31	36°00'06"	105°23'31"	1957	T. Pando	45R	6	7,550	--	--	--	--	D	--	X	--	11
32	36°00'04"	105°23'14"	1957	L. Trujillo	120R	6	7,480	--	--	--	--	D	--	X	--	--
33	36°00'24"	105°22'41"	--	F. Herrera	--	36	7,420	22.8	11-13-68	7,397	Qal	D	500	--	--	--
34	36°00'13"	105°22'32"	1964	Mora Valley Medical Clinic	45R	--	7,410	--	--	--	Qal(?)	D	--	X	13	--
35	36°00'11"	105°22'35"	1967	E. Chacon	53R	--	7,400	--	--	--	Qal(?,	D	--	X	--	60+
36	36°01'26"	105°22'22"	--	--	--	6	7,470	49.2	11-13-67	7,421	--	D	--	--	--	--
37	36°01'27"	105°22'15"	1967	O. Medina	83R	--	7,530	--	--	--	--	D	--	X	--	20
38	36°01'19"	105°21'57"	1957	B. Lujan	131R	6	7,540	--	--	--	--	D	--	X	--	5
39	36°01'05"	105°22'17"	--	A. D. Maes	77	36	7,470	54.3	11-13-67	7,416	Qal	D,O	650*	--	13	--
40	36°01'06"	105°22'16"	1957	C. Pais	105R	6	7,470	--	--	--	Qal(?)	D	--	X	--	5
41	36°01'04"	105°22'18"	--	No. Cleveland MDWCA	--	6	7,470	50	9- 4-69	7,420	Qal(?)	PS,U	650	--	13	--
42	36°00'11"	105°22'10"	--	P. Lujan	37R	24	7,400	18.1	11-13-68	7,382	--	D	680	--	13	--
43	35°59'09"	105°25'24"	1959	H. O. Grace	52R	6,5	8,060	--	--	--	--	D	--	X	--	12
44	35°59'38"	105°22'17"	--	C. D. Romero	20	36	7,380	14.5	11-13-68	7,366	Qal	D	320	--	12	--
46	35°59'13"	105°21'39"	--	J. Karavus	16.5	--	7,350	14.1	11-13-68	7,336	Qal	D	650	--	10	--
47	35°50'02"	105°21'42"	1962	Pendleton Oil & Gas Co.	50R	6	7,330	23.7	3-27-69	7,306	Qal	D,O	205*	X	--	25
48	35°58'52"	105°21'39"	1960	I. Maestas	61R	6	7,315	--	--	--	Qal	D	--	X	--	40
49	35°58'48"	105°21'26"	--	--	20	30	7,300	15.9	11-13-68	7,284	Qal	D	220	--	10	--
50	35°58'38"	105°20'47"	--	--	46	5	7,250	41.3	11-14-68	7,209	Qal	D	--	--	--	--
51	35°58'27"	105°19'54"	--	--	22	36	7,190	15.8	11-14-68	7,174	Qal	O	440	--	13	--

Appendix A.--Records of selected wells in the Mora River drainage, western Mora County, N. Mex. - Continued

Well No.	Latitude	Longitude	Date completed	Owner or name	Depth (feet)	Diameter (inches)	Altitude (feet)	Water level			Principal aquifer	Use	Specific conductance (micromhos at 25°C)	Log	Temperature (°C)	Yield (gpm)
								Depth to water (feet)	Date	Altitude (feet)						
52	35°58'16"	105°19'46"	1950	Mora MDWCA	170R	10	7,180	--	--	--	Qal	PS	329	X	--	125
53	35°58'05"	105°19'42"	--	--	--	40	7,170	3.2	11-14-68	7,167	Qal	D,O	440	--	12	--
54	35°57'46"	105°19'06"	--	S. Muniz	35	--	7,180	25.4	3-27-69	7,155	Qal(?)	D,O	290	--	12	--
54A	35°57'47"	105°19'07"	--	do.	28.5	--	7,180	27.9	3-27-69	7,152	Qal(?)	D	466*	--	--	--
55	35°58'12"	105°19'06"	--	E. Herrera	--	48	7,140	.6	11-14-68	7,139	Qal	D	410	--	11	--
56	35°58'05"	105°18'29"	--	J. P. Bert	14	40	7,110	3.5	11-14-68	7,106	Qal	D,I,O	390*	--	13	--
57	35°58'39"	105°18'17"	--	--	18	40	7,150	12.6	11-14-68	7,137	Qal	D,O	800*	--	18	--
58	35°59'02"	105°18'50"	--	--	29	6	7,155	5.6	11-14-68	7,149	Qal	D,O	360	--	13	--
59	35°59'18"	105°19'29"	--	M. Rudolph	--	48	7,175	5.0	11-14-68	7,170	Qal	D,O	--	--	--	--
60	35°59'19"	105°19'29"	--	do.	420R	6	7,180	--	--	--	--	D	360	--	--	30
61	36°00'01"	105°18'05"	--	Mora Rodeo Grounds	182	6	7,310	144	11-14-68	7,166	--	S,PS	240	--	11	11
62	36°00'48"	105°16'20"	--	T. Martinez	52R	40	7,470	38.0	11-15-68	7,432	Qal	D,S	900	--	9	--
63	36°01'00"	105°16'20"	--	A. Martinez	18R	40	7,450	5.7	11-15-68	7,444	Qal	D	1,130	--	7	--
64	36°01'14"	105°16'21"	--	do.	6.7	36	7,445	4.1	11-15-68	7,441	Qal	S	220	--	7	--
65	36°01'49"	105°16'18"	--	--	27R	60	7,475	21.0	11-15-68	7,454	Qal	D,S	510	--	6	--
66	35°57'17"	105°18'10"	--	P. Montano	75R	6	7,235	25	11-14-68	7,210	Qal	D	250	--	10	--
67	35°55'56"	105°17'36"	--	A. Trujillo	23	80	7,310	16.4	11-14-68	7,294	Qal	D	280	--	10	--
68	35°55'34"	105°17'41"	--	D. Chavez	22	36	7,320	17.7	11-14-68	7,302	Qal	D,S	840	--	10	--
69	35°55'01"	105°17'59"	--	M. Tafoya	81	5	7,370	60	11-14-68	7,310	--	D,S,O	300*	X	13	20
70	35°57'24"	105°16'50"	1964	L. Alcone	100R	--	7,110	--	--	--	--	D	--	X	--	2
71	35°56'59"	105°15'57"	1957	--	50R	6	7,070	--	--	--	--	D	420	X	13	--
72	35°57'34"	105°16'58"	--	E. Esabla	--	6	7,100	--	--	--	Qal(?)	D,U	380	--	--	--
72A	35°56'38"	105°15'30"	--	N. Mex. Hwy. Dept.	56R	--	7,050	--	--	--	Qal	D,O	460	--	11	--
73	35°56'02"	105°15'10"	1965(?)	Buena Vista MDWCA	403R	6	7,100	88.0	6- 3-69	7,012	--	D,I,O	650	X	16	--
74	35°54'33"	105°15'09"	--	J. Floris	150R	6	7,050	82.0	6- 3-69	6,968	--	PS	650*	--	--	--
75	35°54'19"	105°15'00"	--	L. Shock	80+	8	7,010	42.1	11-19-68	6,968	--	D	--	--	--	--
76	35°54'00"	105°15'09"	--	--	200R	6	7,080	--	--	--	--	S	--	X	6	30
77	35°56'54"	105°14'49"	--	W. Salman	100+	6	7,080	82.7	11-19-68	6,997	--	S	620	--	10	--
78	35°56'30"	105°14'53"	--	F. Igo	200R	6	7,020	--	--	--	--	D	950	--	11	--
79	35°56'07"	105°14'59"	--	--	12	48	7,020	8.6	11-19-68	7,011	Qal	D	1,000	--	12	--
80	35°55'15"	105°14'58"	--	L. Shock	35	60	6,995	20.9	11-19-68	6,975	Qal(?)	D	900	--	--	20
81	35°54'15"	105°14'43"	--	--	103R	5	6,980	--	--	--	--	D	--	X	--	--

Appendix A.--Records of selected wells in the Mora River drainage, western Mora County, N. Mex. - Continued

Well No.	Latitude	Longitude	Date completed	Owner or name	Depth (feet)	Diameter (inches)	Altitude (feet)	Depth to water (feet)	Water level Date	Water level Altitude (feet)	Principal aquifer	Use	Specific conductance (micromhos at 25°C)	Log	Temperature (°C)	Yield (gpm)
82	35°53'55"	105°13'56"	--	69 Ranch	80R	5	6,940	--	--	--	--	D,U	--	--	--	--
83	35°53'35"	105°11'07"	1959	F. C. Stover	202R	6	6,865	59.8	11-19-68	6,805	--	S	360	x	--	--
84	35°53'27"	105°11'05"	1960	do.	50R	--	6,830	--	--	--	--	--	--	x	--	25
85	35°53'22"	105°11'02"	--	C. H. Penland	200R	8	6,815	11.7	11-19-68	6,803	Qal	U,O	--	--	--	--
86	35°53'18"	105°10'35"	--	do.	12R	--	6,800	--	--	--	Qal	D	2,300*	--	18	--
87	35°53'40"	105°10'35"	1957	F. C. Stover	70R	6	6,850	--	--	--	--	--	--	x	--	12
88	35°53'30"	105°10'53"	--	--	110R	6	6,830	--	--	--	--	--	--	--	--	10
89	35°49'18"	105°00'58"	--	--	24	--	6,490	20.4	11-19-68	6,470	Qal	D	--	--	--	--
90	35°48'54"	105°00'02"	1946	Phoenix Ranch	327	10	6,475	11.9	6- 4-69	6,463	Qal(?)	U,O	--	--	--	--
91	35°48'28"	105°00'25"	--	V. Boney	108R	8	6,475	--	--	--	Qal(?)	D	650	--	16	--
99	35°48'16"	104°58'56"	1967	W. Shoemaker	100R	14	6,425	5.2	11-21-68	6,420	Qal	Irr,O	850	x	11	1,110
100	35°48'19"	104°59'04"	1954(?)	do.	100R	12	6,425	6.2	11-15-68	--	Qal	Irr	--*	--	--	490
101	35°48'24"	104°59'04"	--	Sellman Bros.	50R	6	6,430	--	--	--	Qal	D	700*	--	--	--
102	35°48'40"	104°59'03"	1967	do.	110R	12	6,460	20.5	11-19-68	6,440	Qal	Irr	650	--	14	270
103	35°48'57"	104°59'45"	1947	G. Mitchell	210R	12	6,460	20.0	11-21-68	6,440	Qal	S,Irr	--	--	--	--
104	35°49'11"	104°59'50"	--	--	38	36	6,465	16.2	11-21-68	6,449	Qal	D	750	--	6	--
105	35°47'31"	104°55'57"	--	--	29	8	6,350	22.0	11-21-68	6,328	Qal(?)	D	--	--	--	--
106	35°47'22"	104°55'30"	--	M. Sellman	44	8(?)	6,330	10	11-21-68	6,320	Qal(?)	D	800	--	--	--
107	35°47'45"	104°59'35"	--	Phoenix Ranch	302R	--	6,440	--	--	--	Qal(?)	D,Irr	600	--	--	25
130	36°02'15"	105°22'55"	--	Maestas	16	30	7,540	15.3	4- 9-69	7,525	Qal	D,O	--	--	--	--
131	35°58'30"	105°18'30"	1968	U.S. Geol. Survey	--	2	7,135	4.9	6- 3-69	7,130	Qal	O	--	--	--	--
132	35°58'11"	105°19'07"	1968	do.	--	3	7,140	.1	6- 3-69	7,140	Qal	O	--	--	--	--
133	35°50'46"	105°04'30"	--	--	--	--	6,590	19.8	6- 4-69	6,570	Qal	U,O	--	--	--	--
134	35°55'39"	105°17'33"	--	M. Valdez	23	36	7,320	19.3	4- 9-69	7,301	Qal	D,O	--	--	--	--
135	35°58'16"	105°19'44"	1968	U.S. Geol. Survey	--	3	7,180	2.7	6- 3-69	7,177	Qal	O	--	--	--	--
136	35°48'51"	104°52'31"	--	--	28	8	6,270	10.2	6- 4-69	6,260	Qal	U,O	--	--	--	--
140	35°57'54"	105°19'49"	1968	U.S. Geol. Survey	20	2½	7,220	14.3	10- 2-69	7,206	Qal	O	--	--	--	--
142	35°52'32"	105°02'59"	--	A. Marshall	280	8	7,000	150.8	7-26-56	6,849	--	S	525	--	16	--
143	35°56'44"	104°59'12"	1954	do.	425R	7	7,100	108.0	7-25-56	6,992	--	S	490	--	16	--
144	35°55'24"	105°59'40"	--	do.	270	6	6,920	64.8	7-25-56	6,865	--	S	500	--	21	--
145	35°53'58"	105°00'46"	1957	Nat. Park Service	325	8	6,720	85	8-21-57	6,635	--	--	--	--	--	50
146	36°00'32"	105°17'13"	1969	E. Hanks	150	6	7,390	73	7-31-69	7,317	Qal	U	220	--	14	12-15
150	35°12'47"	105°12'29"	--	--	160R	--	7,025	--	--	--	--	S	--	--	4	--
151	36°02'30"	105°22'30"	1955	Holman MDWCA	154R	10	--	59	11-29-55	--	Qal,Pu	PS	--	--	--	15
152	36°02'00"	105°22'30"	1956	So. Holman MDWCA	95R	6	--	56	2- 3-56	--	Qal	PS	--	--	--	10-20
201	35°57'17"	105°25'57"	1961	W. Sawyer	150R	6	8,500	--	--	--	--	D	--	x	--	1- 2

Appendix A.--Records of selected wells in the Mora River drainage, western Mora County, N. Mex. - Continued

Well No.	Latitude	Longitude	Date completed	Owner or name	Depth (feet)	Diameter (inches)	Altitude (feet)	Water level Depth to water (feet)	Water level Date	Water level Altitude (feet)	Principal aquifer	Use	Specific conductance (micromhos at 25°C)	Log	Temperature (°C)	Yield (gpm)
201A	35°57'13"	105°26'02"	1959	W. Sawyer	300R	6	8,500	--	--	--	--	--	--	X	--	0.5
202	35°57'31"	105°25'42"	1958	R. C. Kay	40R	72	8,300	26.8	11-12-68	8,273	--	s	240	--	12	--
203	35°56'54"	105°23'06"	1963	L. J. Chambard	70R	--	7,680	--	--	--	Qal(?)	--	--	X	--	--
204	35°57'47"	105°22'57"	1954	La Cañada MDWCA	150R	6	7,800	80	--	--	--	PS	520	--	10	--
205	35°56'39"	105°21'42"	1955	R. Romero	150R	6	7,570	74.0	11-12-68	7,496	--	D	480	--	12	--
206	35°56'52"	105°20'56"	--	S. Regenberg	110R	6	7,570	--	--	--	--	D	420	--	13	--
207	35°56'57"	105°20'43"	--	--	9	36	7,560	2.5	11-12-68	7,558	Qal	U	102	--	18	--
208	35°55'58"	105°21'46"	1957	S. Quintana	60R	6	7,480	30.0	11-13-68	7,450	--	D	795	--	12	--
209	35°55'51"	105°22'22"	1956	J. Romero	17	48	7,520	6.6	11-13-68	7,513	Qal	D	240	--	12	--
210	35°55'36"	105°21'52"	1962	T. Abeyta	18	72	7,480	10.0	11-13-68	7,470	Qal	U	--	--	--	--
211	35°55'12"	105°21'25"	1954	Ledoux MDWCA	150R	6	7,440	43.4	11-13-68	7,397	--	PS,O	510*	--	11	--
212	35°55'17"	105°??'44"	--	A. Garcia	13	54	7,340	7.8	11-12-68	7,332	Qal	--	820*	--	10	--
212A	35°56'43"	105°20'43"	1961	do.	125R	6	7,540	--	--	--	--	D	--	X	--	1
213	35°55'08"	105°20'40"	--	--	10	36	7,310	7.2	11-20-68	7,303	Qal	U	--	--	--	--
214	35°54'29"	105°20'44"	--	--	66	72	7,365	54.0	11-20-68	7,306	Qal	D	-- *	--	13	--
215	35°54'04"	105°20'32"	1965	B. Abeyta	100R	6	7,360	55.0	11-13-68	7,305	Qal(?)	--	168	--	10	--
216	35°54'19"	105°19'34"	--	P. Aragon	12	48	7,240	6.0	11-12-68	7,236	Qal	D	240*	--	--	--
217	35°54'20"	105°18'48"	1904	E. Martinez	39	60	7,245	29.4	11-13-68	7,216	Qal	D	--	--	--	--
218	35°54'17"	105°17'59"	1953	A. Nolan	51	48	7,310	32.1	11-13-68	7,278	Qal	D,O	--	--	--	2e
219	35°53'31"	105°18'55"	--	--	25	48	7,205	23.4	11-13-68	7,182	Qal	U,O	--	--	--	--
220	35°52'36"	105°16'10"	1968	T. Ansley	76	6	7,115	50.8	11-13-68	7,064	--	D,O	820*	--	--	--
223	35°52'13"	105°20'48"	1965	M. Garcia	60R	6	7,375	18.0	11-13-68	7,357	Qal	D	--	--	--	2e
224	35°52'12"	105°20'45"	1958	do.	14	42	7,360	8.3	11-13-68	7,352	Qal	D	360	--	9	--
225	35°52'52"	105°19'40"	--	G. Marujo	19.5	36	7,280	6.2	11-12-68	7,274	Qal	D	580	--	10	--
226	35°53'08"	105°20'15"	1966	D. Chavez	100R	6	7,385	25.6	11-13-68	7,359	--	--	180	--	11	24e
227	35°53'04"	105°19'29"	--	--	--	36	7,760	17.8	4-22-69	7,262	Qal	o	--	--	--	--
228	35°57'11"	105°23'29"	--	--	3.5	24	7,760	3.0	4-22-69	7,757	Qal	D,U,O	--	--	--	--
229	35°52'43"	105°22'00"	1965	P. Serna	85R	6	7,590	65.5	4-22-69	7,524	--	D	--	--	--	--
230	35°56'41"	105°22'46"	1968	Cherry	64R	6	7,620	17.5	4-22-69	7,602	Qal(?)	D,O	240*	--	--	--
231	35°53'56"	105°20'18"	--	D. Trujillo	41	36	7,340	37.8	4-22-69	7,302	Qal	D,O	--	--	--	--
232	35°52'58"	105°16'43"	--	--	22	36	7,100	16.9	4-22-69	7,083	Qal	U,O	--	--	--	--
233	35°35'53"	105°16'46"	--	--	18.5	48	7,110	9.0	4-22-69	7,101	Qal	U,O	--	--	--	--
303	36°11'21"	105°14'00"	1955	Romano	12	24	7,765	9.5	11-12-68	7,755	Qal	D,O	120	--	9	3e

Appendix A.--Records of selected wells in the Mora River drainage, western Mora County, N. Mex. - Continued

Well No.	Latitude	Longitude	Date completed	Owner or name	Depth (feet)	Diameter (inches)	Altitude (feet)	Water level Depth to water (feet)	Water level Date	Water level Altitude (feet)	Principal aquifer	Use	Specific conductance (micromhos at 25°C)	Log	Temperature (°C)	Yield (gpm)
303A	36°10'30"	105°14'00"	1971	Guadalupita Corp.	205	6	7,800	28.1	5-27-71	--	Qal	U	--	X	--	1.5
304	36°09'27"	105°13'51"	--	--	20	24	7,590	13.5	11-13-68	7,576	Qal	D	--	--	--	--
305	36°09'16"	105°14'03"	--	--	20R	36	7,585	14.3	11-13-68	7,571	Qal	D	260	--	12	--
306	36°09'00"	105°14'26"	1964	B. Ortega	61R	6	7,620	35.7	11-13-68	7,584	Qal	D,U	--	X	--	1.0sc
307	36°09'00"	105°14'36"	1964	do.	63R	6	7,615	--	--	--	Qal	D	--	X	--	--
308	36°08'54"	105°14'27"	1920	M. Torres	8R	36	7,590	5.0	11-13-68	7,585	Qal	D,S	355	--	9	--
309	36°08'55"	105°14'34"	--	--	10R	48	7,605	5.0	11-13-68	7,600	Qal	D	210	--	6	--
310	36°08'36"	105°14'27"	--	--	30R	6	7,590	--	--	--	Qal(?)	D	--	--	--	--
311	36°08'41"	105°14'51"	--	Fedel	25R	36	7,660	12.0	11-13-68	7,648	Qal	D,S	400	--	10	2
312	36°08'14"	105°14'20"	--	A. Pacheco	180R	6	7,575	--	--	--	--	D	--	X	--	--
313	36°08'13"	105°14'18"	1960	Damacio	37R	36	7,560	32.0	11-13-68	7,528	Qal	U	160	--	13	0.5sc
314	36°08'16"	105°14'06"	--	S. Romero	10.4	36	7,510	6.2	11-13-68	7,504	Qal	D,O	655*	--	10	20
315	36°06'53"	105°12'48"	1968	Serne	51R	6	7,415	8.9	11-13-68	7,406	Qal	D	430	--	9	0.5sc
316	36°01'00"	105°13'41"	1938	Montoya	75R	6	7,120	--	--	--	Qal(?)	D	950	--	11	--
317	36°00'57"	105°13'37"	--	M. Rael	25R	36	7,110	21.0	11-13-68	7,089	Qal	U	870	--	11	--
318	36°00'57"	105°13'37"	1968	do.	56R	6	7,110	20.0	11-13-68	7,090	Qal	D	870	--	11	--
319	36°07'35"	105°14'20"	1965	A. Griego	47	6	7,520	26.0	11-14-68	7,494	--	D	340	--	5	--
320	36°07'12"	105°14'16"	--	Griego	70R	6	7,550	67.5	11-14-68	7,482	--	D	420	--	8	--
321	36°06'39"	105°14'23"	--	M. Herra	--	40	7,505	--	--	--	--	--	210	--	12	--
322	36°06'30"	105°14'22"	--	A. Griego	80R	72	7,485	44.9	11-14-68	7,440	--	D,S	230	--	7	--
323	36°06'18"	105°14'36"	1960	J. C. Sandoval	160R	6,5	7,475	--	--	--	--	D	530	X	9	8
324	36°06'07"	105°14'37"	1966	E. Torrea	65R	6	7,460	--	--	--	--	D,S	530	--	8	0.4sc
325	36°05'00"	105°15'04"	--	--	12	3	7,360	9.6	11-14-68	7,360	Qal	D,I	--	--	--	--
326	36°04'46"	105°15'06"	--	--	23	60	7,360	18.6	11-14-68	7,341	Qal	D	730	--	5	--
327	36°04'43"	105°15'24"	--	--	14.5	48	7,385	8.5	11-14-68	7,377	Qal	U	--	--	--	--
329	36°04'02"	105°15'29"	1948	E. Torrea	21	48	7,345	12.0	11-14-68	7,333	Qal	D,S	860	--	16	5e
330	36°04'05"	105°16'06"	1968	S. Romero	110R	6	7,440	--	--	--	--	--	850	--	8	--
331	36°04'04"	105°16'05"	--	do.	36	48	7,430	23.5	11-14-68	7,406	Qal	D,O	555	--	8	--
332	36°03'54"	105°15'41"	--	--	16	60	7,360	5.6	11-14-68	7,354	Qal	D,S	445	--	11	--
333	36°03'49"	105°16'53"	--	--	64	40	7,470	21.5	11-14-68	7,448	Qal	U	365	--	11	--
334	36°04'24"	105°17'02"	--	--	52R	40	7,540	19.0	11- 4-68	7,521	Qal	D	435	--	11	--
335	36°04'37"	105°17'14"	--	--	14.9	70	7,589	9.8	11-14-68	7,570	Qal	U	--	--	--	--

Appendix A.--Records of selected wells in the Mora River drainage, western Mora County, N. Mex. - Continued

Well No.	Latitude	Longitude	Date completed	Owner or name	Depth (feet)	Diameter (inches)	Altitude (feet)	Water level Depth to water (feet)	Date	Altitude (feet)	Principal aquifer	Use	Specific conductance (micromhos at 25°C)	Log	Temperature (°C)	Yield (gpm)
336	36°03'12"	105°16'05"	--	--	10.5	36	7,410	9.8	11-14-68	7,400	Qal	S	175	--	8	--
337	36°02'58"	105°16'41"	--	--	31	36	7,440	19.5	11-14-68	7,420	Qal	S	--	--	--	--
338	36°02'15"	105°16'23"	--	--	30	36	7,470	25.4	11-14-68	7,445	Qal	U	--	--	--	--
344	36°03'15"	105°16'51"	--	W. Rossitter	125R	6	7,475	32.0	11-15-68	7,543	Qal	S	240	--	7	--
345	36°03'10"	105°17'16"	1961	do.	165R	6	7,530	--	--	--	Qal(?)	D	--	--	--	--
346	36°02'58"	105°10'58"	1952	T. M. Rivers	300R	6	7,338	--	--	--	--	D	460	--	12	--
347	36°02'51"	105°12'38"	1951	R. Andersen	340R	6	7,293	8.0	11-20-68	7,285	--	S	--	--	--	--
348	36°02'29"	105°10'01"	1948	do.	130R	6	7,306	98.0	11-20-68	7,208	--	S,O	300	--	6	--
349	36°02'58"	105°08'23"	1950	W. Salman	244R	6	7,520	190.5	6- 4-69	7,330	--	D,S,O	430*	--	10	--
350	36°03'32"	105°08'16"	1939	F. Vigil	25R	40	7,550	14.1	11-20-68	7,536	Qal	D,S	340	--	10	--
352	35°59'45"	105°12'06"	1956	--	70R	6	7,060	13.1	11-20-68	7,047	--	S	--	--	--	--
353	35°59'31"	105°11'39"	1967	H. Caseus	100R	6	7,042	33.0	11-20-68	7,009	Qal	D,S	--	--	10	--
354	35°59'31"	105°11'40"	1940	do.	35	65	7,045	29.5	11-20-68	7,015	Qal	D,O	600*	--	10	--
355	35°59'26"	105°10'51"	1968	T. Rivera	90R	6	7,055	56.4	11-20-68	6,999	--	D,S	800	--	11	--
356	35°59'29"	105°11'20"	1958	M. Rivera	87R	6	7,030	41.0	11-20-68	6,989	--	D	820	X	15	--
357	35°59'06"	105°11'20"	1952	R. Lambach	--	6	7,005	21.3	11-20-68	6,984	--	D	710	--	12	--
358	36°03'30"	105°07'04"	--	Ojo Feliz MDWCA	7.0	48	7,535	2.5	11-21-68	7,533	Qal	PS	1,010	--	9	--
359	36°04'16"	105°06'31"	--	R. Anderson	47R	6	7,650	39.0	11-21-68	7,621	--	S	540	--	7	--
363	36°03'06"	105°06'53"	--	--	17.8	60	7,495	15.6	11-21-68	7,479	Qal	U	1,100	--	9	--
364	36°02'22"	105°06'32"	1955	J. Vigil	411R	6	7,435	36	11-21-68	7,399	QTb(?)	D	560	--	9	--
365	35°59'56"	105°12'53"	1960	M. Cruz	100R	6	7,080	51.2	11-21-68	7,029	--	D,S	470	X	15	--
366	35°59'33"	105°12'57"	--	A. Duran	160R	6	7,075	--	--	--	--	D	500	--	11	--
367	35°58'22"	105°12'27"	1960	S. Lucero	135R	6	7,040	--	--	--	--	D	640	X	10	--
368	35°58'45"	105°12'31"	1943	C. Barela	20.5	36	7,042	18.5	11-21-68	--	Qal	--	460	--	11	--
369	35°58'52"	105°11'44"	--	--	11.0	40	6,987	5.1	11-21-68	6,982	Qal	U	700	--	11	--
370	35°58'19"	105°12'18"	1932	P. O. Rainsville	61.3	42	7,038	26.6	11-21-68	7,013	Qal	D	490	--	11	--
371	35°58'47"	105°10'10"	--	W. Salman	--	6	7,056	24.7	11-21-68	7,031	Qal	S	500	--	11	--
372	35°56'30"	105°14'05"	1960	do.	450R	6	7,028	--	--	--	Psr	D	1,200*	--	16	--
373	35°56'55"	105°12'28"	--	do.	--	6	7,010	--	--	--	--	D	690	--	11	--
374	35°56'33"	105°11'39"	--	do.	--	6	6,990	--	--	--	--	D	650	--	11	--
375	35°56'12"	105°11'00"	1957	do.	18.1	24	6,920	12.0	11-21-68	6,908	Qal	U	1,000	--	11	--
376	35°58'03"	105°08'08"	--	do.	130R	6	7,014	98.0	11-21-68	6,916	--	S	--	--	--	--

Appendix A.--Records of selected wells in the Mora River drainage, western Mora County, N. Mex. - Concluded

Well No.	Latitude	Longitude	Date completed	Owner or name	Depth (feet)	Diameter (inches)	Altitude (feet)	Depth to water (feet)	Date	Altitude (feet)	Principal aquifer	Use	Specific conductance (micromhos at 25°C)	Log	Temperature (°C)	Yield (gpm)
377	35°59'03"	105°07'33"	--	W. Salman	--	6	7,042	126	11-21-68	6,916	--	S	560	--	16	--
379	35°57'49"	105°09'40"	--	do.	--	6	6,988	--	--	--	--	S	502	--	11	--
381	35°57'04"	105°10'19"	--	do.	--	6	6,890	31.2	11-22-68	6,859	--	D,O	510*	--	14	--
390	36°08'54"	105°15'24"	--	--	22.3	72	7,790	7.0	6- 4-69	7,783	Qal	U,O	--	--	--	--
392	36°01'23"	105°13'39"	--	--	12.3	24	7,140	8.8	6- 4-69	7,131	Qal	S	--	--	--	--
393	36°08'00"	105°19'00"	1957	Guadalupita MDWCA	122R	11	--	--	--	--	--	PS	--	--	--	25
492	35°46'43"	105°00'09"	--	Stage station	31	6	6,475	28.8	11-21-68	6,446	Qal	PS	--	--	--	--
494	35°46'54"	105°59'17"	--	Watrous Trailer Court	--	8	6,425	15.2	11-21-68	6,410	Qal	PS	--	--	--	--
495	35°47'29"	104°58'57"	--	Watrous MDWCA	220R	8	6,425	11.9	3-25-69	6,413	Qsl	PS	830*	--	--	--
496	35°97'29"	104°50'55"	--	Emberg	170R	12	6,410	--	--	--	Qal(?)	PS	540	--	9	--

Appendix B.--Records of selected springs in the Mora River drainage, western Mora County, N. Mex.

EXPLANATION:
Latitude and longitude: Interpolated from 7½-minute USGS topographic quadrangle maps.

Principal aquifer: Qal, alluvium; QTb, basalt; Kd, Dakota Sandstone; Jm, Morrison Formation;
         Pu, Permian rocks, undivided; ℙu, Pennsylvanian rocks, undivided;
         p€u, Precambrian rocks, undivided.

Specific conductance: Field measurements with portable meter. Asterisk (*) indicates chemical
         analysis in Appendix H.

Spring letter	Latitude	Longitude	Topographic situation	Altitude (feet)	Estimated discharge (gpm)	Principal aquifer	Specific conductance (micromhos at 25°C)
A	36°11'36"	105°21'02"	Valley side	8,640	15	Pu	580
B	35°57'29"	105°23'37"	Valley floor	7,805	1	Qal	105
C	35°56'48"	105°22'43"	do.	7,615	-	Qal	180*
D	35°36'40"	105°20'35"	Arroyo	7,530	-	Qal	-
E	35°55'27"	105°20'29"	Edge of valley	7,400	1-2	Qal	100
F	35°53'53"	105°20'22"	Arroyo	7,315	-	Qal	-
G	35°53'02"	105°19'37"	do.	7,245	-	Qal	-
H	35°52'13"	105°20'36"	Valley floor	7,340	-	Qal	360
I	35°53'30"	105°20'14"	Edge of valley	7,140	220	Pu	460
K	36°08'46"	105°15'16"	Pediment	7,750	20	P€u	280
L	35°54'21"	105°01'13"	Arroyo	6,725	.5	Qal-Jm	550
M	35°53'58"	105°01'08"	Valley	6,715	6	QTb-Jm	-
N	35°56'02"	105°04'32"	Canyon	-	.5	-	-
O	35°49'00"	104°55'25"	Base of cliff	6,360	-	Base of Kd	520*
P	35°55'36"	105°02'59"	do.	6,850	4	Kd(?)	-
R	36°09'06"	105°24'47"	Edge of valley	9,560	26	ℙu	400

Appendix C.--Driller's logs of selected wells in the Mora
River drainage, western Mora County, N. Mex.

Stratigraphic unit and material	Thickness (feet)	Depth (feet)
Well 5		
Quaternary System:		
Alluvium:		
Topsoil	2	2
Clay, yellow; and gravel	17	19
Pennsylvanian System:		
Sandia Formation:		
Shale, black	6	25
Shale, black; with lime streaks .	13	38
Shale and clay, black	4	42
Sand, brown	43	85
Shale, black; with lime streaks .	40	125
Well 6		
Old well		82
Pennsylvanian System:		
Sandia Formation:		
Shale and clay, black	38	120
Well 7		
Topsoil	1	1
Pennsylvanian System:		
Sandia Formation:		
Shale, black	179	180
Well 8		
Quaternary System:		
Alluvium:		
Topsoil	10	10
Boulders and soil; shale, black .	20	30
Gravel	6	36
Pennsylvanian System:		
Sandia Formation:		
Shale, black	54	90
Well 9		
Pennsylvanian System:		
Sandia Formation:		
Shale, yellow	18	18
Shale, black; with hard and soft		
streaks	108	126

Appendix C.--<u>Driller's logs of selected wells in the Mora River drainage, western Mora County, N. Mex.</u> - Continued.

Stratigraphic unit and material	Thickness (feet)	Depth (feet)
Well 10		
Topsoil	1	1
Pennsylvanian System:		
Sandia Formation:		
Clay, yellow	24	25
Shale, black; with blue streaks .	55	80
Shale, black; rotten	36	116
Well 12		
Quaternary System:		
Alluvium:		
Topsoil	15	15
Gravel	5	20
Pennsylvanian System:		
Sandia Formation:		
Shale, black	30	50
Well 14		
Quaternary System:		
Alluvium:		
Topsoil	2	2
Sandy clay and gravel	20	22
Pennsylvanian System:		
Sandia Formation:		
Shale, black	54	76
Well 16		
Quaternary System:		
Alluvium:		
Topsoil	2	2
Sand and gravel	34	36
Pennsylvanian System:		
Sandia Formation:		
Shale, black	16	52
Shale, black; hard	27	79
Shale, gray; soft	16	95
Shale, black	30	125

Appendix C.--Driller's logs of selected wells in the Mora
         River drainage, western Mora County, N. Mex. -
         Continued.

Stratigraphic unit and material	Thickness (feet)	Depth (feet)
Well 18		
Topsoil	1	1
Pennsylvanian System:		
Sandia Formation:		
Clay and shale, yellow	9	10
Shale, black	4	14
Shale, yellow	23	37
Shale, black	23	60
Shale, blue; and sandstone, white	9	69
Shale, black; and sandstone	6	75
Sandstone, white	30	105
Well 20		
Quaternary System:		
Alluvium:		
Topsoil	2	2
Sand	8	10
Sand and boulders	30	40
Pennsylvanian System:		
Sandia Formation:		
Yellow clay	10	50
Well 22		
Topsoil	1	1
Pennsylvanian System:		
Sandia Formation:		
Shale, black; hard	26	27
Clay, yellow; and gravel	5	32
Shale, black; hard	36	68
Sandstone, white	32	100

Appendix C.--Driller's logs of selected wells in the Mora
           River drainage, western Mora County, N. Mex.-
           Continued.

Stratigraphic unit and material	Thickness (feet)	Depth (feet)
Well 23		
Quaternary System:		
Alluvium:		
Topsoil	2	2
Clay, red	6	8
Sand and boulders	40	48
Pennsylvanian System:		
Sandia Formation:		
Shale, black	2	50
Well 24		
Quaternary System:		
Alluvium:		
Topsoil, black	8	8
Soil, black; and gravel	30	38
Sandy gravel	11	49
Gravel, hard, cemented	6	55
Pennsylvanian System:		
Sandia Formation and Madera Limestone:		
Clay, yellow	3	58
Limestone	4	62
Gravel and boulders	18	80
Limestone, hard, sandy	5	85
Shale, gray	6	91
Limestone, hard, sandy..........	19	110
Shale, black	37	147
Limestone	3	150
Well 25		
Topsoil	1	1
Pennsylvanian System:		
Sandia Formation:		
Shale, gray	19	20
Shale and clay, black	62	82
Sandy clay, gray	2	84
Sandstone, yellow	21	105
Shale, black	10	115
Sandstone, gray	15	130
Sandstone, yellow	10	140
Shale, black	4	144

Appendix C.--Driller's logs of selected wells in the Mora
River drainage, western Mora County, N. Mex.-
Continued.

Stratigraphic unit and material	Thickness (feet)	Depth (feet)
Well 26		
Quaternary System:		
Alluvium:		
Topsoil	3	3
Clay, gray; and gravel	22	25
Pennsylvanian System:		
Sandia Formation:		
Sandstone, gray; with streaks of clay	37	62
Well 27		
Quaternary System:		
Alluvium:		
Clay, red	18	18
Sandstone and boulders	6	24
Pennsylvanian System:		
Sandia Formation:		
Shale, black	58	82
Well 28		
Quaternary System:		
Alluvium:		
Topsoil	2	2
Sandy clay, brown	10	12
Gravel	23	35
Pennsylvanian System:		
Sandia Formation:		
Clay, black	18	53
Shale, black; hard	37	90
Well 31		
Quaternary System:		
Alluvium:		
Clay, yellow	30	30
Pennsylvanian System:		
Sandia Formation:		
Shale, black	15	45

Appendix C.--Driller's logs of selected wells in the Mora
River drainage, western Mora County, N. Mex.-
Continued.

Stratigraphic unit and material	Thickness (feet)	Depth (feet)
Well 32		
Quaternary System:		
Alluvium:		
Clay, red	8	8
Clay, yellow	29	37
Pennsylvanian System:		
Sandia Formation and Madera Limestone:		
Shale, black	20	57
Sandstone and shale	5	62
Sandstone, white	13	75
Shale, black	20	95
Sandstone, white	1	96
Shale, black	9	105
Sandstone, white	9	114
Shale, pink	6	120
Well 34		
Quaternary System:		
Alluvium:		
Topsoil	2	2
Clay, brown; and gravel..........	22	24
Gravel	18	42
Clay and sand, red	3	45
Well 35		
Quaternary System:		
Alluvium:		
Topsoil	2	2
Clay, sandy	16	18
Clay and gravel	7	25
Clay, sandy	10	35
Clay and gravel	18	53
Well 37		
Old well	76	76
Pennsylvanian System:		
Sandia Formation:		
Sandstone, yellow and white	7	83

Appendix C.--Driller's logs of selected wells in the Mora River drainage, western Mora County, N. Mex.- Continued.

Stratigraphic unit and material	Thickness (feet)	Depth (feet)
Well 38		
Quaternary System:		
Alluvium:		
Clay and sand	30	30
Permian and Pennsylvanian Systems:		
Sangre de Cristo Formation:		
Clay, red and yellow	58	88
Sandstone, broken	4	92
Shale, red and blue	28	120
Pennsylvanian System:		
Sandia Formation:		
Shale, black	11	131
Well 40		
Quaternary System:		
Alluvium:		
Topsoil	2	2
Clay, red	4	6
Sand and boulders	24	30
Pennsylvanian System:		
Sandia Formation:		
Shale, black	75	105
Well 43		
Quaternary System:		
Alluvium:		
Topsoil	1	1
Boulders	12	13
Clay, black	2	15
Sand and gravel	15	30
Pennsylvanian System:		
Sandia Formation:		
Shale, yellow	5	35
Granite, decomposed	12	47
Shale, black	5	52

Appendix C.--Driller's logs of selected wells in the Mora
River drainage, western Mora County, N. Mex.-
Continued.

Stratigraphic unit and material	Thickness (feet)	Depth (feet)
Well 47		
Quaternary System:		
Alluvium:		
Topsoil	2	2
Gravel and boulders	48	50
Well 48		
Quaternary System:		
Alluvium:		
Topsoil	2	2
Boulders	38	40
Sand and gravel	21	61
Well 52		
Quaternary System:		
Alluvium:		
Soil, black loam	6	6
Sand and gravel	6	12
Boulder, large	68	80
Gravel, fine	10	90
Gravel, blue	10	100
Pennsylvanian System:		
Sandia(?) Formation:		
Limestone, black	20	120
Limestone, brown	30	150
Granite	10	160
Clay, yellow	5	165
Lime shell	5	170
Well 70		
Quaternary System:		
Alluvium:		
Topsoil	4	4
Clay, gray; and gravel	26	30
Gravel	2	32
Sand	10	42
Pennsylvanian System:		
Sandia(?) Formation:		
Shale, black	40	82
Sandstone, white	18	100

Appendix C.--<u>Driller's logs of selected wells in the Mora</u>
<u>River drainage, western Mora County, N. Mex.</u>-
Continued.

Stratigraphic unit and material	Thickness (feet)	Depth (feet)
Well 71		
Permian and Pennsylvanian Systems:		
Sangre de Cristo Formation:		
Clay, red	8	8
Sandstone, red; soft	12	20
Shale, red	5	25
Sandstone, red; soft	25	50
Well 73		
Quaternary System:		
Alluvium:		
Clay, gummy and sticky	4	4
Sandy clay, brown with broken sand- stone and occasional small gravel	6	10
Triassic System:		
Santa Rosa Sandstone:		
Shale, red, firm	27	37
Sandstone, yellow, occasional seams of blue and red shale	17	54
Sandstone, gray and blue, very hard	6	60
Sandstone, tan, hard, with traces of red shale	15	75
Sandstone, blue, very hard and fine grained; occasional seam of shale	26	101
Sandstone, gray and yellow, hard and fine grained; seams of blue and red shale	7	108
Sand, brown, tight, with clay seams	7	115
Sandstone, brown and yellow, hard	11	126
Sandstone, very hard, traces of blue and gray shale	7	133
Shale, soft	32	165
Shale, varicolored, hard	66	231
Sandstone, gray, very hard	11	242
Shale, varicolored, hard, seams of sandstone and clay	32	274
Sandstone and shale, hard	11	285
Sandstone, soft	5	290
Sandstone and shale seams, alter- nating hard and soft	53	343

Appendix C.--<u>Driller's logs of selected wells in the Mora</u>
          River drainage, western Mora County, N. Mex.-
          Continued.

Stratigraphic unit and material	Thickness (feet)	Depth (feet)
Well 73 - Concluded		
Sandstone and shale layers, soft, occasional seams of hard shale	27	370
Sandstone and shale, hard, fractured	27	397
Sandstone, porous, and hard shale	6	403
Well 76		
Topsoil	2	2
Triassic System:		
Chinle Formation:		
Sandstone	10	12
Shale and clay, gray	38	50
Sandstone, yellow	60	110
Shale, gray and red	5	115
Sandstone, yellow	20	135
Sandstone, white	5	140
Sandstone, yellow	40	180
Sandstone, dark white	5	185
Lime, blue	5	190
Shale, red	10	200
Well 81		
Old well	65	65
Jurassic System:		
Morrison(?) Formation:		
Sandstone, red	15	80
Sandstone, white	13	93
Clay, red	10	103
Well 83		
Cretaceous System:		
Graneros Shale and Greenhorn Limestone:		
Limestone and streaks of gray shale	50	50
Slate, blue	50	100
Shale, blue; rotten	75	175
Limestone streaks and shale	27	202

Appendix C.--Driller's logs of selected wells in the Mora River drainage, western Mora County, N. Mex.-Continued.

Stratigraphic unit and material	Thickness (feet)	Depth (feet)
Well 84		
Quaternary System:		
Alluvium:		
Topsoil	1	1
Clay, black	9	10
Clay, yellow	5	15
Boulders and gravel	10	25
Cretaceous System:		
Graneros Shale:		
Shale, black; hard	25	50
Well 87		
Quaternary System:		
Alluvium:		
Topsoil	5	5
Clay, black	3	8
Clay, red	24	32
Cretaceous System:		
Graneros Shale:		
Shale, black	38	70
Well 99		
Quaternary System:		
Alluvium:		
Topsoil	30	30
Sand and gravel	30	60
Cretaceous System:		
Graneros Shale:		
Clay and shale, blue	40	100
Well 201		
Quaternary System:		
Landslide deposits:		
Granite boulders, blue	7	7
Clay, blue	10	17
Pennsylvanian System:		
Madera Limestone and Sandia Formation:		
Limestone, blue	33	50
Sandstone, yellow	20	70
Limestone, blue	15	85
Shale, blue	70	150

Appendix C.--<u>Driller's logs of selected wells in the Mora</u>
<u>River drainage, western Mora County, N. Mex.</u>-
Continued.

Stratigraphic unit and material	Thickness (feet)	Depth (feet)
Well 201A		
Pennsylvanian System:		
Sandia Formation:		
Sandstone, coarse	27	27
Shale, black	24	51
Sandrock, white; hard	41	92
Shale, black	20	112
Sandrock	73	185
Shale, black	115	300
Well 203		
Quaternary System:		
Alluvium:		
Topsoil	4	4
Sand and gravel, coarse	31	35
Clay and gravel	6	41
Clay and large boulders	19	60
Pennsylvanian System:		
Sandia Formation:		
Sandstone	10	70
Well 212A		
Quaternary System:		
Alluvium:		
Topsoil	2	2
Clay, yellow	23	25
Precambrian:		
Mica(?)	100	125
Well 303A		
Quaternary System:		
Alluvium:		
Topsoil	1	1
Boulders	87	88
Sand and gravel	56	144
Yellow clay	4	148
Boulders and sand	14	162
Yellow sandstone	28	190
Pretty clean sand	12	202

Appendix C.--<u>Driller's logs of selected wells in the Mora River drainage, western Mora County, N. Mex.</u>-Continued.

Stratigraphic unit and material	Thickness (feet)	Depth (feet)
Well 306		
Quaternary System:		
Alluvium:		
Topsoil	1	1
Clay and boulders	9	10
Precambrian:		
Mica	51	61
Well 307		
Quaternary System:		
Alluvium:		
Topsoil	3	3
Gravel and boulders	30	33
Sand and gravel	28	61
Precambrian:		
Mica	2	63
Well 312		
Quaternary System:		
Alluvium:		
Clay, brown	10	10
Clay and gravel	20	30
Pennsylvanian System:		
Sandia Formation:		
Shale, black	30	60
Shale, white	10	70
Shale, black	110	180
Well 323		
Quaternary System:		
Alluvium:		
Clay, yellow; and gravel	65	65
Sandstone and gravel	95	160

Appendix C.--<u>Driller's logs of selected wells in the Mora</u>
<u>River drainage, western Mora County, N. Mex.-</u>
Concluded.

Stratigraphic unit and material	Thickness (feet)	Depth (feet)
Well 356		
Quaternary System:		
Alluvium:		
Clay, red	25	25
Gravel	4	29
Triassic System:		
Chinle Formation:		
Clay, red; and gravel	58	87
Well 365		
Quaternary System:		
Alluvium:		
Topsoil	2	2
Clay, yellow	8	10
Sand, gravel, and boulders	15	25
Sandstone, red	60	25
Clay, red	15	100
Well 367		
Quaternary System:		
Alluvium:		
Topsoil	2	2
Clay, yellow	8	10
Sand and boulders	15	25
Triassic System:		
Chinle(?) Formation:		
Sandstone, red	60	85
Shale	15	100
Clay	35	135

Appendix D.--Records of test holes drilled in the Mora River drainage, western Mora County, N. Mex.

EXPLANATION:
Formation at total depth: Qal, alluvium; Kgr, Graneros Shale; ₽u, Pennsylvanian rocks, undivided; p€u, Precambrian rocks

Test hole number	Latitude	Longitude	Total depth (feet)	Casing diameter (inches)	Water level above (+) or below (-) land surface (feet)	Formation at total depth	Yield (gpm)	Remarks
M -1	36°00'20"	105°22'59"	40	1¼	-11	₽u	12-14	--
M -1a	36°00'20"	105°22'59"	22	2	- 7	₽u	-	--
M -2	35°53'04"	105°11'02"	25	1¼	-15	Kgr	1.5	Yield estimated
M -2a	35°53'15"	105°10'59"	15	1¼	-10	Kgr	1.5	Do.
M -3	35°58'48"	105°19'32"	35	1¼	Flowing	Qal	-	--
M -3a	35°58'48"	105°19'32"	30	2	Do.	Qal	2.6	--
M -4	35°59'57"	105°18'09"	61	None	Dry	p€u	Dry	--
M -5	35°58'37"	105°18'44"	65	1¼	Flowing	Qal	.5	Two casing strings in hole; one set at 65 ft. and one at 15 ft. No yield was obtained from casing set at 15 ft.

Appendix D.--Records of test holes drilled in the Mora River drainage, western Mora County, N. Mex. - Concluded

Test hole number	Latitude	Longitude	Total depth (feet)	Casing diameter (inches)	Water level above (+) or below (-) land surface (feet)	Formation at total depth	Yield (gpm)	Remarks
C -1	35°55'35"	105°21'28"	8	None	- 6	Qal	-	--
C -2	36°56'14"	105°21'11"	15	do.	- 5	Qal	-	--
Cy-1	36°07'56"	105°13'59"	20	2	+.20	p€u	1.9	--
Cy-1a	36°07'56"	105°13'59"	20	2	+.20	p€u	1.9	--
Cy-2	36°04'49"	105°14'50"	50	4	- 8	p€u	-	--

Appendix E.--<u>Size analyses of samples from test holes in</u>
<u>the Mora River drainage, western Mora County,</u>
<u>N. Mex.</u>

Depth of sample (feet)	Gravel % (>2.0 mm)	Sand % (0.065-2.0 mm)	Silt-clay % (<0.0625 mm)
	Test hole M-1		
0- 5	5.25	38.98	55.77
5-10	11.77	35.71	52.52
10-15	37.90	33.35	28.75
15-35	No sample		
35-40	68.47	19.95	11.58
	Test hole M-2		
0- 5	75.09	19.48	5.43
5-10	No sample		
10-15	3.57	20.22	76.21
15-20	9.58	22.06	68.36
20-25	No sample		
	Test hole M-2a		
0- 5	42.86	40.84	16.30
5-10	39.79	46.54	13.67
10-15	11.63	31.88	56.49
	Test hole M-3		
0- 5	0.33	38.91	60.76
5-10	.58	31.31	68.11
10-35	No sample		
	Test hole M-4		
0- 5	2.54	51.81	45.65
5-10	No sample		
10-15	4.26	48.53	47.21
15-20	40.65	31.63	27.72
20-25	14.01	51.35	34.64
25-30	17.23	46.26	36.51
30-45	9.45	52.87	38.68
45-55	No sample		
55-61	38.83	32.43	29.74
	Test hole M-5		
0- 5	6.70	59.94	33.36
5-10	17.19	39.68	43.13
10-65	No sample		
	Test hole Cy-1		
0- 5	9.07	42.10	38.83
5-10	31.45	37.19	32.36
10-20	No sample		

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Appendix E.--<u>Size analyses of samples from test holes in</u>
<u>the Mora River drainage, western Mora County,</u>
<u>N. Mex. - Concluded</u>

Depth of sample (feet)	Gravel % (>2.0 mm)	Sand % (0.065-2.0 mm)	Silt-clay% (<0.0625 mm)
	Test hole Cy-2		
0- 5	6.05	59.62	34.33
5-10	7.27	52.50	40.23
10-15	5.25	55.75	39.00
15-20	17.97	56.72	25.31
20-25	2.61	45.37	52.02
25-30	4.16	58.04	37.80
30-35	.98	29.15	69.87
35-40	3.56	48.77	47.67
40-50	No sample		

Appendix F.--Records of pumping tests made on wells and test holes in the Mora River drainage, western Mora County, N. Mex.

Well 99

Owner: J. W. Shoemaker
Date of test: September 25, 1969
Method of discharge
  measurement: Free fall jet; checked by
                                   propeller-type meter
Measuring point: Hole in pump base 1 foot above
                                   land-surface datum.
Saturated thickness at beginning of test: 55 feet

Pumping period

Time since pumping started (minutes)	Depth to water below measuring point (feet)	Drawdown (feet)	Discharge (by free fall) (gpm)
0	6.45	0	-
.3	23.15	16.70	-
1	20.95	14.50	-
2	21.55	15.10	-
3	21.93	15.48	-
4.5	21.72	15.27	-
6	21.65	15.20	1,060
8	21.29	14.84	-
10	21.65	15.20	-
14	21.62	15.17	-
22	21.85	15.40	-
26	21.82	15.37	-
30	21.58	15.13	-
35	21.60	15.15	-
40	21.45	15.00	910
50	21.81	15.36	-
60	21.55	15.10	-
70	21.71	15.26	950
85	21.50	15.05	-
102	21.55	15.10	-
115	21.57	15.12	-
130	21.65	15.20	920
145	21.67	15.22	-
160	21.30	14.85	870
175	21.30	14.85	890
190	21.46	15.01	-
205	21.67	15.22	870
220	21.80	15.35	-
235	21.85	15.40	-

Discharge check with meter averaged 1,100 gpm.

Appendix F.--Records of pumping tests made on wells and
test holes in the Mora River drainage,
western Mora County, N. Mex. - Continued

Well 99 - Concluded

Recovery period

Time since pumping stopped (minutes)	Time since pumping started / Time since pumping stopped (minutes)	Depth to water below measuring point (feet)	Residual drawdown (feet)
0	--	21.85	15.40
.117	5,002	20.00	13.55
.250	1,608	17.50	11.05
.383	1,060	15.00	8.55
.917	438	13.00	6.55
1.50	269	11.65	5.20
2	202	11.17	4.72
3	135	10.55	4.10
4	101.5	10.28	3.83
5	81.4	10.00	3.55
6	68.0	9.95	3.50
8	51.2	9.77	3.32
10	41.2	9.70	3.25
12	34.5	9.67	3.22
15	27.8	9.66	3.21
20	21.1	9.45	3.00
25	17.1	9.30	2.85
30	14.4	9.21	2.76
40	11.1	8.98	2.53
50	9.04	8.90	2.45
60	7.70	8.77	2.32
75	6.35	8.60	2.15
90	5.47	8.50	2.05

Well 100

Measurements in observation well 100
when pumping well 99
Distance from pumped well: 300 feet
Measuring point: Top of casing 0.8 feet
above land-surface datum

Time since pumping started (minutes)	Depth to water below measuring point (feet)	Drawdown (feet)
22	6.70	0
24	6.69	+ .01
37	6.69	+ .01
57	6.57	+ .13

Appendix F.--Records of pumping tests made on wells and
test holes in the Mora River drainage,
western Mora County, N. Mex. - Continued

Well 100 - Continued

Time since pumping started (minutes)	Depth to water below measuring point (feet)	Drawdown (feet)
71	6.70	+ .05
132	6.71	.01
146	6.75	.05
163	6.77	.07
176	6.79	.09
191	6.77	.07
206	6.79	.09
221	6.84	.14
236	6.83	.13

Well 100 - Concluded

Owner: J. W. Shoemaker
Date of test: November 15, 1968
Method of discharge
  measurement: Free fall jet; checked by propeller-
                                           type meter
Measuring point: Top of casing 0.8 foot above land-
                                           surface datum

Pumping period

Time since pumping started (minutes)	Depth to water below measuring point (feet)	Drawdown (feet)	Discharge (gpm)
0	7.00	0	450
14	17.40	10.40	450
16	18.00	11.00	450
18	18.50	11.50	450
20	18.70	11.70	450
25	20.50	13.50	450
32	18.60	11.60	fluctuating
38	19.80	12.80	Do.
45	20.25	13.25	Do.
55	20.35	13.35	Do.

Discharge check with meter averaged 490 gpm.

Appendix F.--Records of pumping tests made on wells and
test holes in the Mora River drainage,
western Mora County, N. Mex. - Continued

Well 102

Owner:	Sellman Brothers
Date of test:	November 15, 1968
Method of discharge measurement:	Free fall jet; checked by propeller-type meter
Measuring point:	Top of casing 1 foot above land-surface datum

Pumping period

Time since pumping started (minutes)	Depth to water below measuring point (feet)	Drawdown (feet)	Discharge (by free fall) (gpm)
0	22.07	0	220
1	27.00	4.93	220
3	27.80	5.70	220
6	28.30	6.20	220
10	28.70	6.60	220
15	29.28	7.21	220
20	29.53	7.46	220
30	29.90	7.83	220
40	30.25	8.18	220
60	30.60	8.53	220

Note: Discharge by propeller-type meter averaged 270 gpm.

Test hole Cy-1 and observation well Cy-1a

Date of test:	October 3, 1969
Method of discharge measurement:	Volumetric

Observation well (Cy-1a) 29.5 ft. from pumped well (Cy-1)
Saturated thickness in both wells at start of test: 20 ft.

Pumping period

Time since pumping started in test hole Cy-1 (minutes)	Depth to water above (+) or below land surface in observation well Cy-1a (feet)	r^2/t	Drawdown in obser-vation well Cy-1a (feet)	Discharge from test hole Cy-1 (gpm)
0	+0.58	0	0	0
3	2.08	290	1.50	2
3.5	2.22	249	1.64	2
4	2.40	218	1.82	2
4.5	2.51	193	1.93	2

Appendix F.--Records of pumping tests made on wells and
test holes in the Mora River drainage,
western Mora County, N. Mex. - Continued

Test hole Cy-1 and observation well Cy-1a - Continued

Pumping period - Concluded

Time since pumping started in test hole Cy-1 (minutes)	Depth to water above (+) or below land surface in observation well Cy-1a (feet)	r^2/t	Drawdown in observation well Cy-1a (feet)	Discharge from test hole Cy-1 (gpm)
5	2.62	174	2.04	2
5.5	2.69	158	2.11	2
6	2.76	145	2.18	2
7	2.86	124	2.28	2
8	2.97	109	2.39	2
9	3.05	96.7	2.47	2
10	3.13	87.0	2.55	2
12	3.28	72.5	2.70	2
14	3.35	62.2	2.77	2
16	3.48	54.4	2.90	1.8
18	3.75	48.3	3.17	1.82
20	3.93	43.5	3.35	1.82
23	4.07	37.8	4.39	1.82
26	4.02	33.5	3.44	1.82
29	4.02	30.0	3.44	1.82
32	3.95	27.2	3.37	1.82
35	3.87	24.9	3.29	1.82
37	4.28	23.5	3.70	2.22
40	4.57	21.8	3.99	2.22
45	4.81	19.3	4.23	2.22
50	4.88	17.4	4.30	2.35
55	5.00	15.8	4.42	2.35
60	4.91	14.5	4.33	2.35
70	5.01	12.4	4.43	2.35
80	4.85	10.9	4.27	2.35
90	4.32	9.67	3.74	2.35

Appendix F.--<u>Records of pumping tests made on wells and</u>
<u>test holes in the Mora River drainage,</u>
<u>western Mora County, N. Mex. - Concluded</u>

<u>Test hole Cy-1 and observation well Cy-1a - Concluded</u>

Measuring point: Top of casing 4 feet above land-surface
datum

<u>Recovery period, pumped well (Cy-1)</u>

Time since pumping stopped (minutes)	Time since pumping started / Time since pumping stopped (minutes)	Depth to water below measuring point (feet)	Residual drawdown (feet)
0.67	135.5	9.40	5.60
1	91	8.55	4.75
1.5	61	8.12	4.32
2	46	7.85	4.05
2.5	37	7.47	3.67
3	31	7.40	3.60
4	23.5	7.02	3.22
5	19	6.81	3.01
6	16	6.65	2.85
7	13.85	6.48	2.68
9	12.4	6.24	2.44
11	11.2	6.00	2.20
13	10.3	5.83	2.03
15	7	5.70	1.90
20	5.5	5.40	1.60
25	4.6	5.25	1.45
30	4	5.00	1.20

Note: Static water level: 3.80 feet below measuring point.

Appendix G.--Records of water levels in observation wells in the Mora River drainage, western Mora County, N. Mex.

Well No.	Owner or name	Date (1969)	Depth to water (feet)	Date (1969)	Depth to water (feet)	Date (1969)	Depth to water (feet)	Date (1969)	Depth to water (feet)	Date (1969)	Depth to water (feet)	Date (1969)	Depth to water (feet)	Date (1969)	Depth to water (feet)
4	Old School	4- 9	24.9	6- 3	23.7	7- 9	29.1	7-31	24.5	9- 4	22.8	10- 2	24.5	11- 6	30.5
11	W. Romero	4- 2	6.6	6- 3	6.8	7- 9	6.7	7-31	6.8	9- 4	6.0	1´ 2	6.4	11- 6	5.6
15	N. Lovato	4- 9	16.4	6- 3	17.2	7- 9	17.2	7-31	18.4	9- 4	12.6	10- 2	18.9	11- 6	18.5
39	A. D. Maes	4- 9	63.4	6- 3	46.8	7- 9	38.7	Replaced by No. 41		-		-		-	-	-
41	No. Cleveland MDWCA	-	-	-	-	-	-	8- 1	48.1	9- 4	51.1	-		-	-	-
47	Pendleton Oil & Gas Co.	3-27	23.7	6- 3	19.2	7- 9	22.5	8- 1	21.8	9- 4	23.3	10- 2	24.8	11- 7	21.9
51	-	3-27	14.9	6- 3	12.4	7- 9	7.5	8- 1	8.9	9- 4	11.7	10- 2	13.3	11- 7	13.7
53	-	3-27	3.4	6- 3	.9	7- 9	.4	8- 1	.4	9- 4	2.5	10- 2	1.6	11. 7	2.2
54	S. Muniz	3-27	25.4	6- 3	25.0	7- 9	22.4	8- 1	20.7	9- 4	20.6	10- 2	14.0	11- 6	18.1
56	J. P. Bert	3-27	3.8	6- 3	3.9	7- 9	3.5	8- 1	3.5	9- 4	2.7	10- 2	3.8	11- 6	3.5
57	-	3-27	13.9	6- 3	12.7	7- 9	12.6	8- 1	12.6	9- 4	12.9	10- 2	12.7	11- 6	12.8
58	-	3-27	4.4	6- 3	5.2	7- 9	5.1	8- 1	5.1	9- 4	5.3	10- 2	5.3	11- 6	4.7
69	D. Chavez	4- 9	25.4	6- 3	25.8	7- 9	26.2	8- 1	26.2	9- 4	24.2	10- 2	26.4	11- 6	25.2
73	N. Mex. Hwy. Dept.	4- 9	88.0	6- 3	88.0	-	-	-	-	-	-	-	-	-	-
74	Buena Vista MDWCA	3-27	85.2	6- 3	82.0	7- 8	90.0	7-31	83.5	-	-	10- 2	82.6	-	-
85	C. H. Penland	3-25	12.4	6- 4	11.6	7- 8	10.8	7-30	11.5	9- 4	11.6	10- 2	12.1	-	-
90	Phoenix Ranch	3-25	14.9	6- 4	11.9	7- 8	11.6	7-30	11.0	-	-	10- 2	11.6	-	-
99	J. Shoemaker	3-25	4.4	6- 4	4.4	7- 8	5.5	₵ 7-30	5.0	9- 4	5.1	10- 2	5.3	11- 6	5.4
130	Maestas	4- 9	15.3	6- 3	12.6	7- 9	11.1	8- 1	10.2	9- 4	10.6	10- 2	12.3	11- 6	9.3
131	USGS	3-28	5.9	6- 3	4.9	7- 9	4.4	8- 1	4.2	9- 4	3.9	10- 2	4.6	11- 6	3.3
132	do.	-	-	6- 3	.1	7- 9	.2	8- 1	Flow	9- 4	-	10- 2	Flow	11- 6	Flow
134	M. Valdez	4- 9	19.3	6- 3	20.5	7- 9	19.8	8- 1	20.6	9- 4	19.5	10- 2	19.2	11- 6	18.5
135	USGS	-	-	6- 3	2.7	7- 9	1.0	8- 1	1.6	9- 4	1.5	10- 2	4.1	11- 6	4.9
136	-	-	-	6- 4	10.2	-	-	7-30	10.3	9- 4	9.4	10- 2	11.9	11- 6	12.0
140	USGS	-	-	-	-	-	-	8- 1	10.5	9- 4	12.7	10- 2	14.3	11- 6	15.6
211	Ledoux MDWCA	4-22	49.2	6- 3	40.6*	7- 9	39.0	8- 1	*	9- 5	35.8	10- 1	40.4	11- 6	37.7
218	A. Nolan	4-22	58.8	6- 3	51.0	7- 9	38.2	8- 1	31.9	9- 5	29.6	-	-	11- 6	32.4
219	-	4-22	24.0	6- 3	20.3	7- 9	22.1	8- 1	24.7	9- 5	24.7	10- 1	24.4	11- 6	20.0
220	T. Ansley	4-22	52.7	6- 3	49.0	7- 9	48.8	8- 1	47.6	-	-	10- 1	49.4	11- 6	45.3
227	-	4-22	17.8	6- 3	15.9	7- 9	17.2	8- 1	20.2	9- 5	17.6	10- 1	17.5	11- 6	16.4
228	-	4-22	3.0	6- 3	3.6	7- 9	Dry	-	-	-	-	-	-	-	-
230	Cherry	4-22	17.5	6- 3	8.3	7- 9	2.2	8- 1	1.7	9- 5	.6	10- 1	4.7	-	-
231	D. Trujillo	4-22	37.8	6- 3	25.9	7- 9	20.0	8- 1	17.4	9- 5	17.2	10- 1	21.9	11- 6	23.3
232	-	4-22	19.9	6- 3	10.6	7- 9	10.4	8- 1	10.7	-	-	10- 1	10.8	-	-
303	Romano	3-27	12.4	6- 4	12.3	7- 9	12.6	7-31	11.8	9- 5	12.7	No measurement, redrilling		11- 7	10.5
314	S. Romero	4- 9	6.1	6- 4	7.5	7- 9	8.1	7-31	7.7	9- 5	6.9	10- 3	8.3	11- 7	7.1
331	do.	3-25	33.1	6- 4	32.1	7- 8	32.0	7-31	32.0	9- 5	26.3	10- 1	27.5	11- 7	27.5
338	-	4- 9	30.6	6- 4	28.0	7- 8	26.8	7-31	26.1	9- 5	21.6	10- 1	23.5	11- 6	19.3
348	R. Anderson	4- 9	97.6	6- 4	99.0	7- 8	98.6	-	-	9- 5	97.1	10- 1	*	11- 6	*
349	W. Salman	4- 9	157.0	6- 4	190.5	7- 8	190.3	7-30	180.6	9- 5	179.6	10- 1	*	11- 6	*
354	H. Caseus	3-25	35.3	6- 4	32.6	7- 8	28.2	7-30	34.4	9- 5	35.2	10- 1	35.3	-	-
381	W. Salman	4- 9	30.7	6- 4	26.8	7- 8	21.5	-	-	-	-	-	-	-	-
390	do.	-	-	6- 4	7.0	7- 9	8.9	7-31	6.9	-	-	10- 1	13.7	11- 7	15.3
495	Watrous MDWCA	3-25	11.9	6- 4	30.7*	7- 8	8.4	7-31	11.2	9- 4	7.2	10- 2	11.8	11- 6	8.2

*Pumping water level, or no measurement due to pumping.

Appendix H.--Chemical analyses of water samples from wells, streams, and springs in the Mora River drainage, western Mora County, N. Mex.
(Chemical constituents are in milligrams per liter)

EXPLANATION:
Source of sample: Number of wells and letters of springs correspond to those in Appendixes A and B, and on figure 14.
Principal aquifer:: Qal, alluvium; Kgr, Graneros Shale ; Kd, Dakota Sandstone; Rc, Chinle Formation; Rsr, Santa Rosa Sandstone; Pu, Pennsylvanian rocks, undivided.

Source of sample	Date of collection	Temperature °C	Silica (SiO$_2$)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Boron (B)	Bicarbonate (HCO$_3$)	Carbonate (CO$_3$)	Sulfate (SO$_4$)	Chloride (Cl)	Fluoride (F)	Nitrate (NO$_3$)	Dissolved solids	Calcium Magnesium	Noncarbonate	Percent Sodium	Sodium adsorption ratio (SAR)	Specific conductance (micromhos at 25°C)	pH	Principal aquifer
Well 11	7-31-69	18	16	1.80	4.6	2.6	394		0.53	596	43	282	9.6	3.9	0.1	1,050	22	0	97	36	1,380	8.8	Pu
Well 15	1-31-69	12	15	-	95	26	23		.08	288	0	141	2.8	.4	4.2	449	342	106	13	.5	689	7.6	Qal
Well 39	8-1-69	14	16	-	128	6.0	0		.05	310	0	68	3.6	.4	16	390	344	90	0	0	662	7.4	Qal
Well 47	8-1-69	17	16	-	34	.2	6		.01	100	0	15	.6	.2	0	121	86	4	13	.3	180	7.2	Qal
Well 54A	8-1-69	12	30	-	55	7.1	33		.06	172	0	34	15	2.1	44	305	166	25	30	1.1	458	7.3	Qal
Well 56	8-1-69	16	12	-	100	.6	20		.04	224	0	73	18	.7	9.8	344	252	68	15	.5	546	7.9	Qal
Well 57	11-27-68	17	56	.04	9.5	4.5	177	4.6	.36	212	0	80	83	17	.9	537	42	0	89	12	843	7.4	Qal
Well 69	8-1-69	18	21	-	44	6.3	14		.02	180	0	10	4.6	.7	.3	190	136	0	18	.5	302	8.0	Qal
Well 74	7-31-69	19	17	-	102	11	32		.05	310	0	75	13	.7	21	424	300	46	19	.8	671	7.4	Rc(?)
Well 86	7-30-69	19	13	.07	461	53	83		.14	300	0	1,080	8.4	.4	20	1,810	1,220	974	13	1.0	2,090	7.7	Qal & Kgr
Well 100	10-9-69	12	18	-	104	25	30		.11	360	0	104	9.2	.6	6.2	477	362	62	15	.7	803	7.6	Qal
Well 101	11-27-68	11	16	.00	98	17	32	1.1	.11	319	0	109	6.7	.4	2.8	440	316	54	18	.8	701	7.5	Qal
Well 211	8-1-69	13	21	-	85	3.4	15		.02	292	0	9.6	2.8	.8	4.2	286	226	0	13	.4	462	7.8	Qal
Well 212	11-27-68	10	17	.00	61	12	87	1.2	.11	194	0	156	30	2.2	37	499	202	43	48	2.7	755	7.5	Qal
Well 214	11-27-68	11	17	.00	62	4.3	7.2	3.0	.11	210	0	19	1.8	.7	1.9	220	172	0	8	.2	361	7.5	Qal
Well 216	11-27-68	8	27	.00	37	7.7	14	2.7	.10	87	0	32	13	.5	45	222	124	52	19	.5	335	7.1	Qal
Well 220	8-1-69	23	15	.08	152	6.1	35		.05	302	0	80	37	.3	119	593	404	156	16	.8	870	7.6	Qal & Pu
Well 230	8-1-69	15	14	-	40	2.4	8.3		.01	142	0	6.4	2.0	.3	1.3	145	110	0	14	.3	238	6.8	Qal(?)
Well 314	11-27-68	-	11	.40	24	4.9	73	3.4	.14	247	0	18	4.1	.4	17	277	80	0	65	3.6	450	7.7	Qal
Well 349	7-30-69	17	26	.05	62	12	19		.03	256	0	22	5.4	.4	5.4	278	204	0	17	.6	435	7.9	Rsr
Well 354	7-30-69	12	20	.05	72	19	31		.05	316	0	27	9.0	.4	29	362	256	0	21	.9	576	8.2	Qal
Well 372	11-27-68	-	14	.00	130	40	105	3.3	.21	412	0	288	41	.5	1.5	827	490	152	32	2.1	1,210	7.7	Kz & Rsr
Well 381	7-30-69	16	19	-	60	15	42		.07	288	0	46	7.6	.6	10	342	212	0	30	1.3	524	7.9	Qal
Well 495	7-30-69	-	15	-	80	22	75		.13	308	0	170	15	1.0	.4	530	290	38	36	1.9	829	7.9	Qal
Spring C	11-27-68	4	2.8	.06	32	7.8	7.6	3.0	.09	130	0	14	5.0	.4	1.1	138	112	6	12	.3	249	7.1	Qal
Spring Q	7-30-69	-	25	-	85	5.8	24		.06	276	0	32	16	.9	4.4	329	236	10	18	.7	570	8.0	Base of Kd
Rito Cebolla at State Hwy.3	11-27-68	3	21	.00	62	15	18	1.8	.13	244	0	47	6.6	.4	.2	292	216	16	15	.5	477	7.9	-
Rito Cebolla near Well 212	11-27-68	9	13	.25	60	9.8	16	1.3	.11	250	0	16	3.5	.6	0	244	190	0	15	.5	415	7.9	-
Luna Cr. at Hwy. 121	10-10-69	7	7.6	-	68	13	13		.06	207	7	64	1.0	.2	.1	276	222	52	11	.4	428	8.4	-
Mora River at Hwy. 38	10-10-69	11	8.5	-	68	17	13		.06	224	0	77	1.6	.2	.7	296	239	56	10	.4	483	8.2	-